MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

MONAN

Model for Ocean-laNd-Atmosphere predictioN

The 1st Community Training of MONAN/MPAS-A
12-16 August 2024 CPTEC/INPE

Saulo R. Freitas
On behalf of the Scientific Steering Committee

MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA,TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The Climate Change and the Climate Emergency

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

“Extreme events cause record rains and hundreds of deaths in Brazil”

Bahia – 27 mortes Dez/2021

M. Gerais – 19 mortes JAN/2022

Petrópolis (RJ) - 230 mortes Jan/2022

S. Paulo – 34 mortes Fev/2022

Pernambuco – 128 mortes Maio/2022

Litoral Norte de SP ~ 60 mortes Fev/2023

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

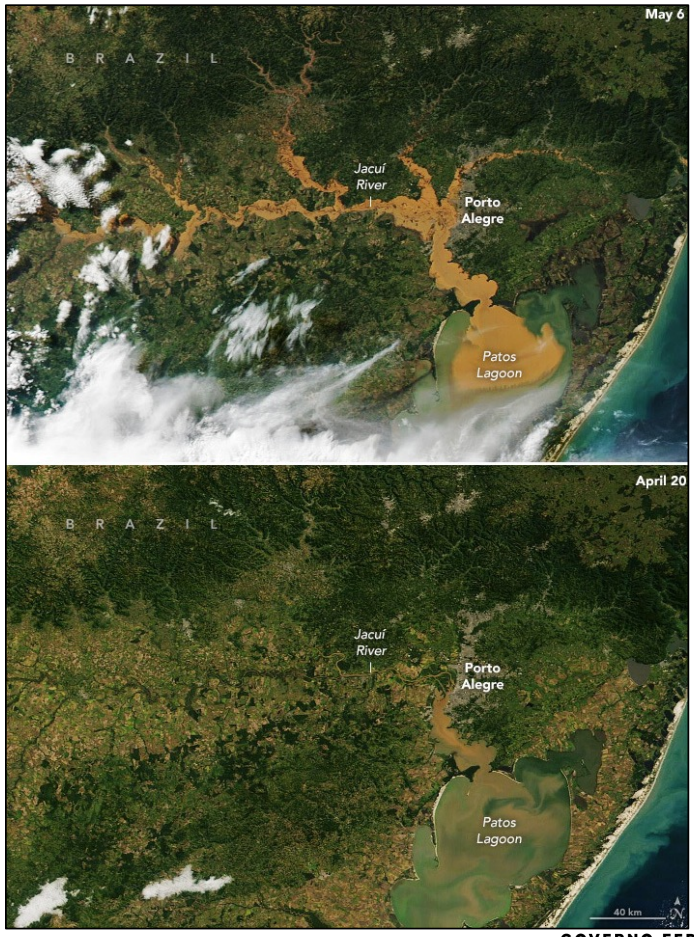
Contributing to MONAN

How to contribute to MONAN Model

1. Fork the MONAN-Model repository to your Github account
2. Develop, test your code in develop branch
3. Ensure the model works as before when not using your part of the code
4. **Synchronize your fork with the oficial repository**
5. Commit and push to your fork
6. Create a Pull Request from your account

Recent Extreme Weather Events @ South of Brazil
May 2024

More than 90% of the *Rio Grande do Sul* state being affected by flooding.



MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Historical perspective of the costs of environmental disasters in Brazil

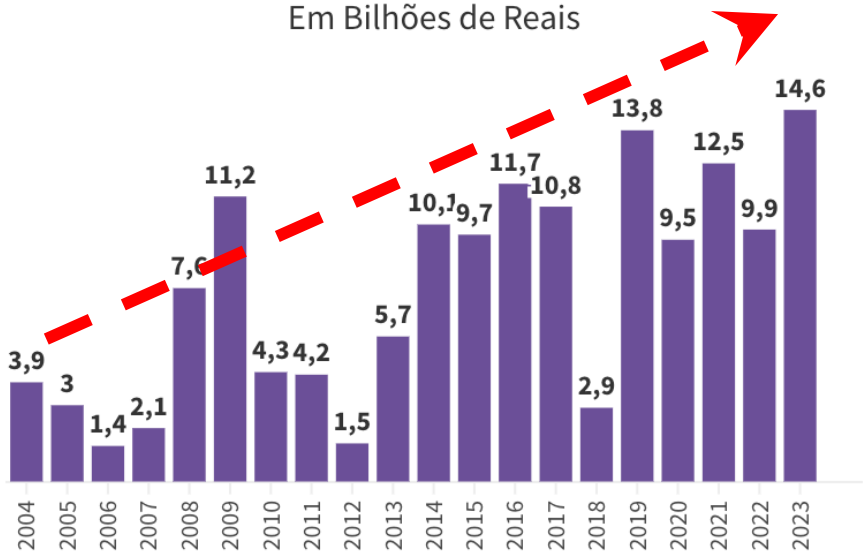
R$ 150 bilhões: Custo de desastres com chuvas no país salta 41% em 10 anos

Wanderley Preite Sobrinho • Do UOL, em São Paulo
25/05/2024 04h00

Ruas alagadas na cidade de Canoas, no Rio Grande do Sul
Imagem: Wesley Santos

Prejuízos em desastres com chuva* disparam no Brasil

Em Bilhões de Reais



Fonte: Atlas Digital de Desastres no Brasil (Ministério do Desenvolvimento Regional),

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The Inequity of the Extreme Weather Events

May create divergent situations at the extremes,

but, mostly converging to penalize the poorest populations!

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Humankind, more than ever,
needs better,
more useful,
reliable,
and timely
climate information
for protection and mitigation against adverse related phenomena.

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

How to effectively advance in the numerical forecast of the atmosphere and its interfaces?

We need focus in all three directions:

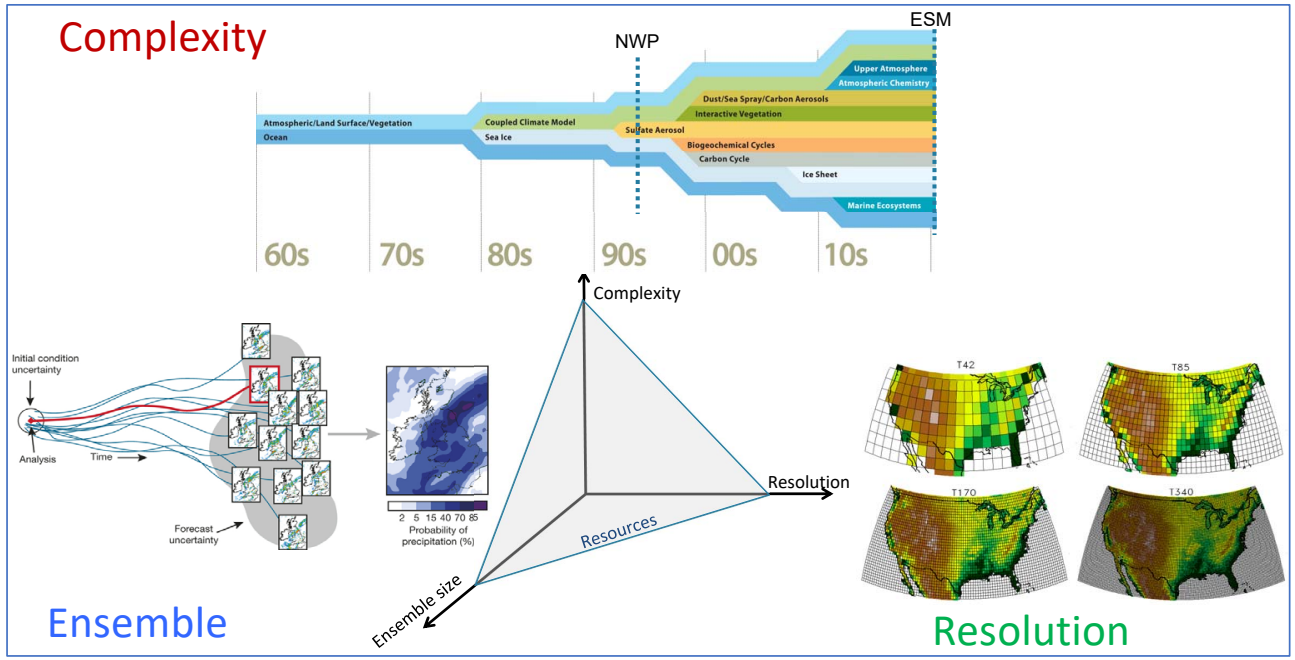


Figure adapted from J.-F. Lamarque (NCAR)

MONAN
Model for Ocean-laNd-Atmosphere predictioN

This entire framework assisted by:

- Access, treatment, and storage of observational data;
- Data assimilation at different levels of complexity;
- High-performance computing service, management of complex software (codes with millions of lines);
- Analysis and quantitative evaluation of model results;
- Post-processing, use of IA, interpretation, publication of forecasts;
- Methodologic management of activities, processes, and routines;
- Efficient and transparent communication with society and stakeholders.

Modeling Activities in Brazil (*)

Models	Type – Time scales	Institution
MCGA - BAM	Global Atmospheric model medium range - subseasonal - seasonal	INPE/CPTEC
BRAMS	Regional Atmos + Chem + Aer + CarbCycle medium range	INPE/CPTEC, Universities, Regional NWP centers
Eta	Regional Atmospheric medium range – seasonal	INPE/CPTEC and Universities
WRF	Regional Atmospheric medium range	INPE/CPTEC, Universities, Regional NWP centers
COSMO	Regional Atmospheric medium range	INMET (Brazilian National Inst of Meteorology)
ROMS+WRF	Regional O-A Coupled Research	INPE/DIOTG
BAM+MOM5 (BESM)	Global O-A Coupled seasonal	INPE/CPTEC

MONAN
Model for Ocean-laNd-Atmosphere predictioN

(*) not exhaustive

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

What was proposed in 2021, and what are we working on?

A new paradigm of focus and organization for advancing the numerical weather, climate, and environment forecasting in Brazil.

MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

MONAN

Model for Ocean-laNd-Atmosphere predictioN

In the **MONAN project,** Brazil adopt a unified and community Earth System model
Everyone work on a single modeling system, a single computational code

1. **It involves the most relevant Earth System components:**
   a) Atmosphere, biosphere and continental soils, cryosphere, oceans, upper space.
   b) Anthropogenic disturbances relevant to the dynamics of the natural system (anthroposphere).
2. **Unified:**
   a) Suitable for spatial scales of atmospheric phenomena on the order of 10^2 m to 10^3 km.
   b) Suitable for temporal scales of nowcasting, weather, sub-seasonal, seasonal and climate change.
3. **Accurate:**
   a) Reduced number of approximations and use of state-of-the-art numerical methods for solving differential equations in supercomputers.
   b) Anchored in a robust Data Assimilation System using remote sensing and local observations.
   c) Enhanced with Artificial Intelligence/Machine Learning techniques.
4. **Community model:**
   a) Open source with free and public access.
   b) Workshops and training for the community.
5. Multi-Institutional Governance:
   a) Scientific steering committee formed by representatives of operational and research centers, academy and stakeholders.

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

How do we organize ourselves for this project?

Scientific Steering Committee of the Earth System Community Model

- Created on April 8, 2021 by the Director of INPE (Dr. Clezio De Nardin)
- Participating Institutions: INPE, INMET, LNCC, INPA, CENSIPAM, DECEA, Army Forces and several Universities

Current Members of SSC

Membros internos ao INPE:

1. Saulo R. Freitas
2. Antonio Ocimar Manzi
3. Caio Coelho
4. Carlos Bastarz
5. Chou Sin Chan
6. Renato Galante
7. Haroldo Fraga de Campos Velho
8. João Gerd
9. Joaquim Eduardo Rezende Costa
10. Jorge Luis Gomes
11. Karla Longo
12. Luciano Pezzi
13. Luiz Flávio Rodrigues
14. Paulo Kubota
15. Ronald Buss de Souza
16. Celso Luiz Mendes

Membros externos:

1. Pedro Dias (IAG/USP)
2. Afonso Paiva (COPPE-UFRJ)
3. Enio Pereira de Souza (UFCG)
4. Flávia Rodrigues Pinheiro (Marinha do Brasil)
5. Gilberto Bonatti (INMET)
6. Hélio Abreu Nogueira (FAB)
7. Ivan Saraiva (CENSIPAM)
8. Julia Cohen (UFPA)
9. Luiz Cândido (INPA)
10. Luiz Cláudio Oliveira Andrade (Exército)
11. Marcia Yamasoe (IAG/USP)
12. Fabrício Harter (UFPel)
13. Pedro Peixoto (IME/USP)
14. Ricardo de Camargo (IAG/USP)
15. Roberto P. Souto (LNCC)
16. Vinícius Capistrano (UFMS)
17. Francisco C. Vasconcelos Jr (FUNCEME)
18. Yanina Skabar (SMN Argentina)

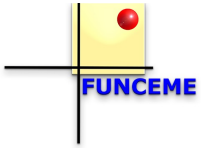
MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Who is already working with us?

Departamento de Controle
do Espaço Aéreo



FUNCEME - FUNDAÇÃO CEARENSE DE
METEOROLOGIA E RECURSOS HÍDRICOS

MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO

We are negotiating collaboration with

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

WORLD METEOROLOGICAL ORGANIZATION

NASA Goddard SPACE FLIGHT CENTER

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

ECMWF
European Centre for Medium-Range Weather Forecasts

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Funding and Resources for MONAN's Development and Operational Implementation

MONAN was approved as a

- Strategic Program by the Brazilian Minister of Science and Technology (Federal level)
- 10-year Work Plan (2022-2031)
- Annual budget ~ US$ 170,000

RISC – MONAN Proposal (2023-2026) – Lead by Dr. Ivan Barbosa

- Funded by FINEP Brazilian Agency with ~ US$ 40 million over four years
  - US$ 24 million for the next supercomputer (first partition arriving in the next January)
  - US$ 4 million for the model and software infrastructure development (starting next year)
  - US$ 11 million for solar energy power plant, maintenance, etc.

CAPES/CNPq Brazilian Funding Agencies ~ US$ 280,000 (2024-2026)

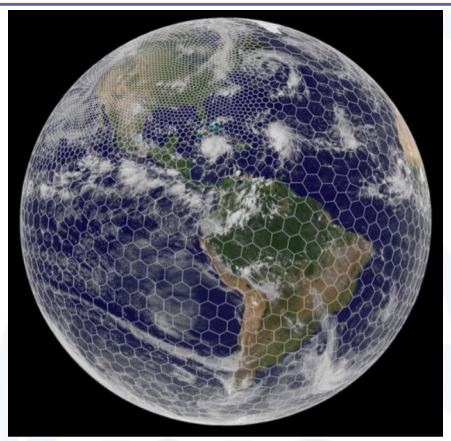
- Scholarships for five PostDocs overseas
- Two PhD "sandwich" scholarships overseas
- Training workshops for the South America community

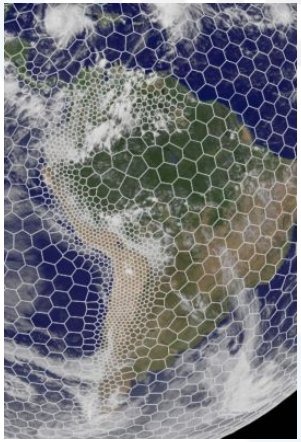
MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

The choice of the atmospheric component of MONAN

The candidates for the basis of the next-generation GCM (MONAN) in Brazil: MPAS and SHiELD



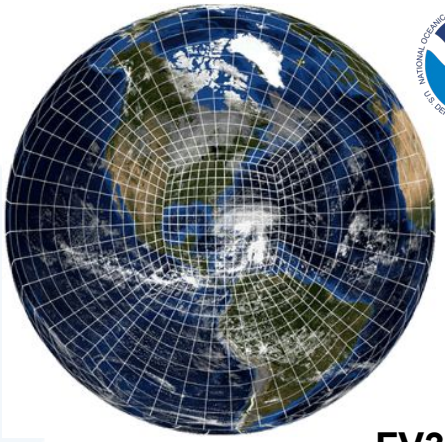


MPAS

Voronoi Grid

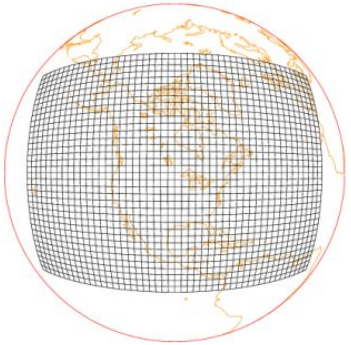
NCAR

Model for Prediction Across Scales



FV3

Finite-Volume Cubed-Sphere Dynamical Core



MONAN
Model for Ocean-laNd-Atmosphere predictioN

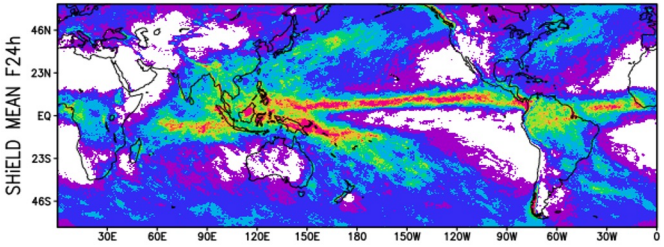
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

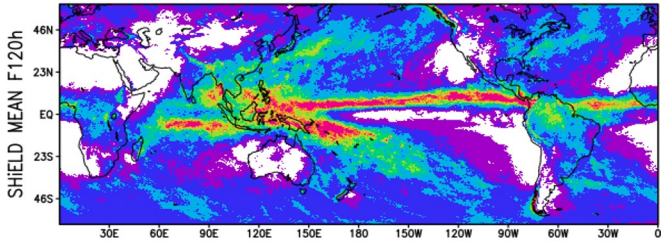
Mean Global Precipitation

mm/day

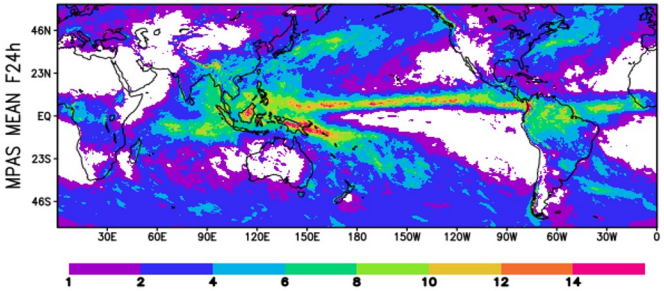
SHiELD 24h



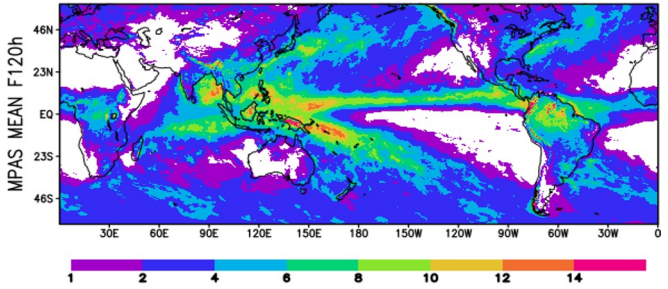
SHiELD 120h



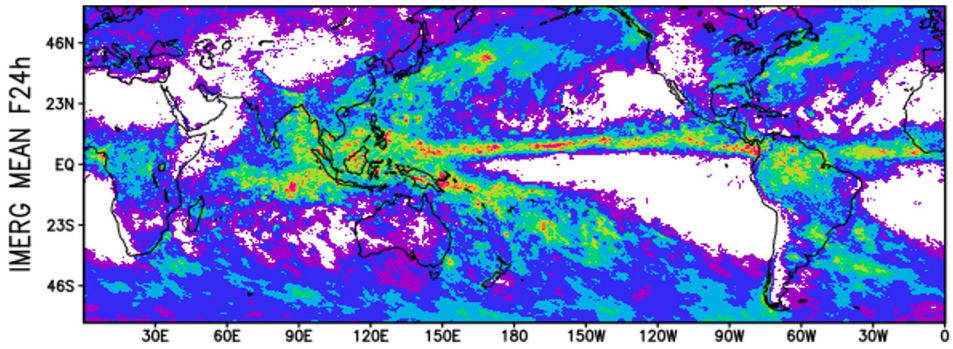
MPAS 24h



MPAS 120h



GPM-IMERG



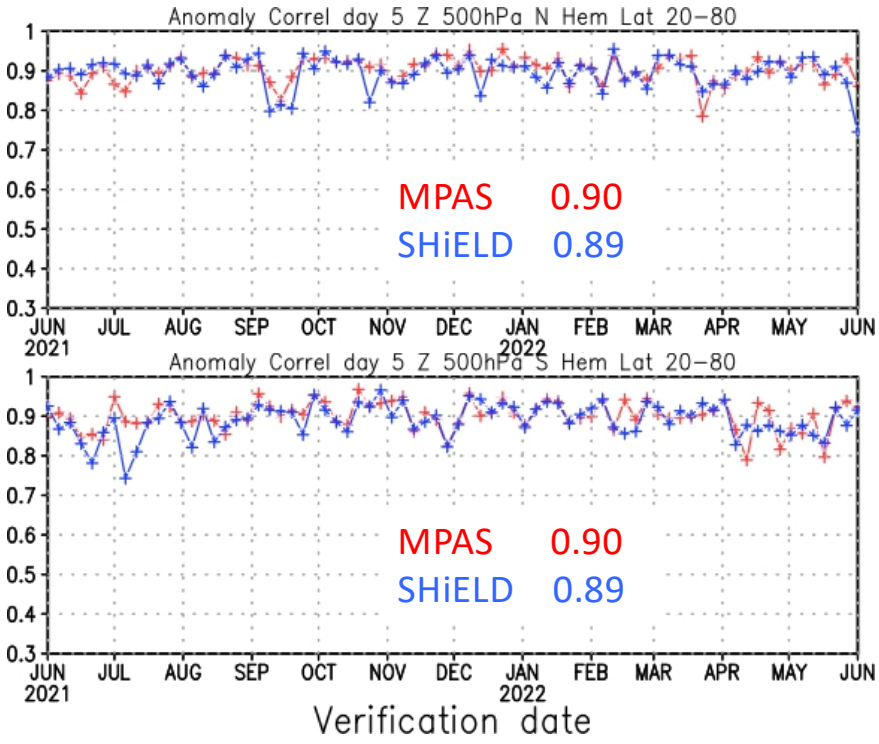
MONAN
Model for Ocean-laNd-Atmosphere predictioN

Modeling Evaluation Group /DIMNT/INPE

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Geopotential Height Anomaly Correlation @ 500 hPa
Forecast Day 5 (74 cases)



N. Hem.

S. Hem.

MONAN
Model for Ocean-laNd-Atmosphere predictioN

Modeling Evaluation Group /DIMNT/INPE

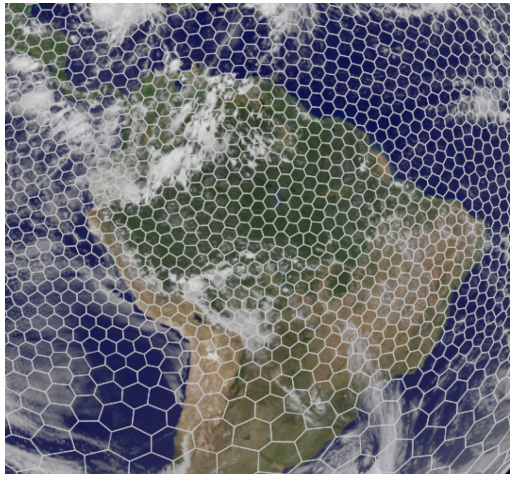
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

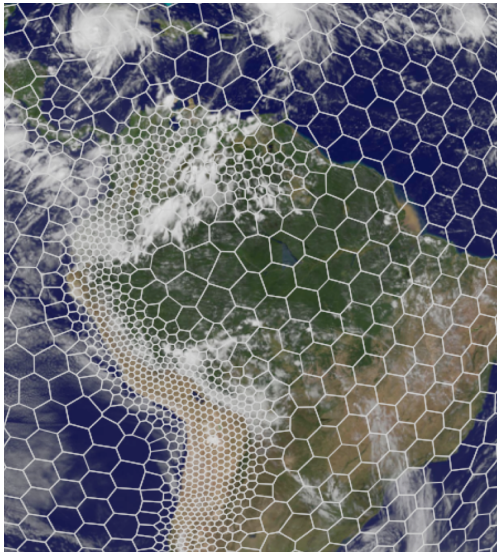
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The Atmospheric Component of MONAN

1. The MPAS-A was officially indicated by the working group at INPE, mostly
   a) Software design with modern Fortran features.
   b) Portability for GPU.
   c) The WRF legacy 1: the most successful regional model ever developed in the world.
   d) The WRF legacy 2: a large part of the South America community modeling uses it.
   e) Successful application in convection-allowing scales.

2. On 03 August 2023, the Scientific Committee of MONAN approved this indication.





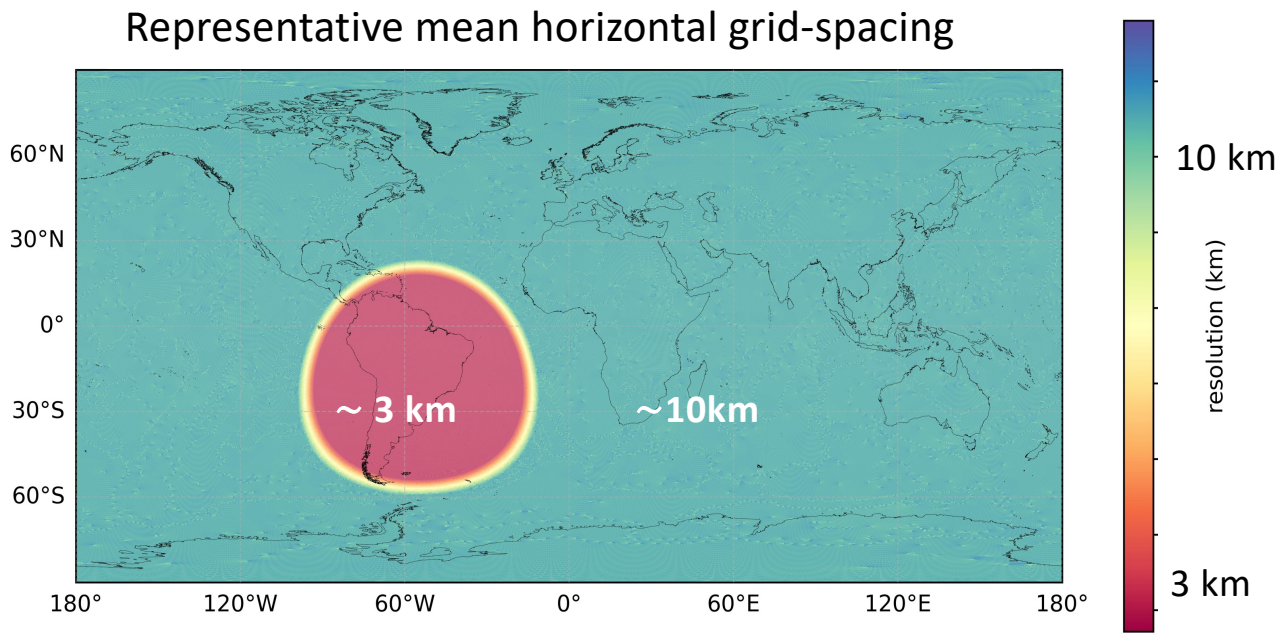
MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Our target:

Weather prediction on a global scale, but with focus on South America



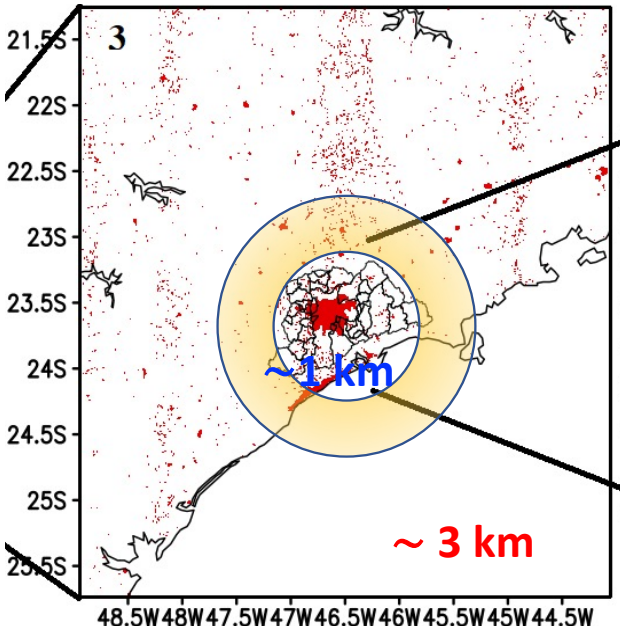
MONAN
Model for Ocean-laNd-Atmosphere predictioN

Figure provided by P. Peixoto (2023) IME/USP

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Interlocution with the National Meteorology Network and Regional Centers (operational and academic)

Environmental Prediction on a Regional/Local Scale



Example for the Metropolitan Region of São Paulo for implementation by regional centers

- Methods:
  - Initial and boundary conditions with analysis/forecasts produced with CPTEC/INPE's global **MONAN**;
  - Addition of weather radar data assimilation for nowcasting with the regional configuration of **MONAN.**
- Products:
  - Weather products (including severe weather);
  - Air quality and public health;
  - Biometeorology (thermal comfort indicators, heat waves, UV radiation);
  - Forecast of energy production (solar, wind);
  - Ocean waves;
  - ?

MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The 1st Training of MONAN/MPAS-A

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The 1st Training – Institutions Participants

Participarão do treinamento 30 pesquisadores, professores ou tecnologistas:

- MCTI, USP, UFRJ, CEMPA, UFRN, UFBA, UNESP, UFCG, UFPel, Marinha Brasileira, FUNCEME, UFMS, FURG, CENSIPAM, Força Aérea Brasileira, UFAL, UNIFESP, UFPA e LNCC.
- Instituto de Geofísica e SENAMHI do Peru
- Serviço Meteorológico da Argentina

The 1st Training – Institutions Participants

Participarão do treinamento 30 pesquisadores, professores ou tecnologistas:

- MCTI, USP, UFRJ, CEMPA, UFRN, UFBA, UNESP, UFCG, UFPel, Marinha Brasileira, FUNCEME, UFMS, FURG, CENSIPAM, Força Aérea Brasileira, UFAL, UNIFESP, UFPA e LNCC.
- Instituto de Geofísica e SENAMHI do Peru
- Serviço Meteorológico da Argentina

NCAR
Operated by UCAR

MONAN
Model for Ocean-laNd-Atmosphere predictioN

The 1st Training – List of Participants

1	Antonio Marcos Mendonça	MCTI	Brasil
2	Ana Maria Bueno Nunes	UFRJ	Brasil
3	Angel Domínguez Chovert	CEMPA	Brasil
4	Berlin Segura	IGP- Perú	Perú
5	Claudio Moisés Santos e Silva	UFRN	Brasil
6	Clemente Augusto Souza Tanajura	UFBA	Brasil
7	Cynthia Matsudo	SMN	Argentina
8	Danilo Couto de Souza	USP	Brasil
9	Demerval Soares Moreira	UNESP	Brasil
10	Enio Pereira de Souza	UFCG	Brasil
11	Fabricio Harter	UFPel	Brasil
12	Flávia Rodrigues Pinheiro	MB	Brasil
13	Francisco Chagas Vasconcelos Junior	FUNCEME	Brasil
14	Jorge Armando Ordoñez Piscoya	SENAMHI	Perú
15	Josivaldo Lucas Galvão Silva	UFMS	Brasil

16	Juliana Costi	FURG	Brasil
17	Maicon Eirolico Veber	DIPTC	Brasil
18	Marcelo Felix Alonso	UFPel	Brasil
19	Marcia Akemi Yamasoe	USP	Brasil
20	Márcio Nirlando Gomes Lopes	CENSIPAM	Brasil
21	Maria Luciene Dias de Melo	UFAL	Brasil
22	Nilton Manuel Evora do Rosario	UNIFESP	Brasil
23	Paulo Afonso Fischer Kuhn	UFPA	Brasil
24	Paulo Geovani Iriati	FAB	Brasil
25	Paulo Maurício Moura de Souza	CENSIPAM	Brasil
26	Pedro da Silva Peixoto	USP	Brasil
27	Roberto Pinto Souto	LNCC	Brasil
28	Simone Marilene da Costa Coelho	DISSM	Brasil
29	Felipe Augusto de Bragança Alves	USP	Brasil
30	Guilherme Luiz Torres Mendonça	USP	Brasil

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The Program: 12 – 14 August 2024
Focus on MPAS GCM

Monday, 12 August 2024

08:30-09:00 Registration
09:00-09:30 Overview of the MONAN program (A)
09:30-10:00 Opening Remarks by the host Institution (A)
10:00-10:20 MPAS Overview (A)
10:20-10:35 Downloading and compiling MPAS-Atmosphere (A)
10:35-10:45 Break
10:45-11:30 Dynamics and dynamics configuration (A)
11:30-12:00 Physics and physics configuration (A)
12:00-13:30 Lunch
13:45-14:40 Running MPAS, part 1: Initialization and running a basic global simulation (A)
14:40-15:00 Introduction to the practical exercises (A)
15:00-15:45 Running MPAS, part 2: Variable-resolution, I/O streams, restarts, and other options (A)
15:45-16:00 Practical session (TR)
16:00-16:10 Break
16:10-17:00 Practical session (TR)

Tuesday, 13 August 2024

09:00-09:30 An overview of the structure of MPAS meshes (A)
09:30-10:00 Running MPAS, part 3: Preparing limited-area meshes and LBCs (A)
10:00-10:30 Post-processing and visualizing MPAS-Atmosphere output (A)
10:30-10:45 Break
10:45-11:25 Spatial discretization, filters and transport (A)
11:25-12:00 Unique aspects of MPAS code: Registry, pools, and logging (A)
12:00-13:30 Lunch
13:45-14:25 Adding passive tracers to MPAS-Atmosphere simulations (A)
14:25-15:00 Computing new diagnostic fields in MPAS-Atmosphere simulations (A)
15:00-16:00 Practical session (TR)
16:00-16:10 Break
16:10-17:00 Practical session (TR)

Wednesday, 14 August 2024

09:00-09:20 MPAS mesh generation (A)
09:20-09:55 New MPAS capabilities under development, and concluding remarks (A)
09:55-10:15 MONAN 1.0.0 overview and future plans(A)
10:15-10:35 Overview of MONAN implementation (A)
10:35-10:45 Break
10:45-12:00 Practical session - MPAS mesh generation (TR)
12:00-13:30 Lunch
13:45-16;00 Monan Regional Model Trainning (TR)
16:00-16:15 Break
16:15-16:55 Monan Regional Model Trainning (TR)
16:55-17:15 Registering MONAN workshop group photograph
17:15-19:00 Ice break

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA,TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The Program: 15 – 16 August 2024
Focus on the MPAS-JEDI DAS

Thursday, 15 August 2024

09:00-10:00 Fundamentals of Data Assimilation (A)
10:00-10:35 MPAS-JEDI overview and introduction to practical exercises (A)
10:35-10:45 Break
10:45-11:15 Observations (1): Converting BUFR observations to IODA format & HofX Application (A)
11:15-12:00 Practical session (code build/ctest, observations conversion, HoFX (TR)
12:00-13:30 Lunch
13:45-14:15 Algorithms (1): 3D/4DEnVar (A)
14:15-16:00 Practical session (TR)
16:00-16:10 Break
16:10-17:00 Practical session (3D/4DEnVar with conventional observations) (TR)

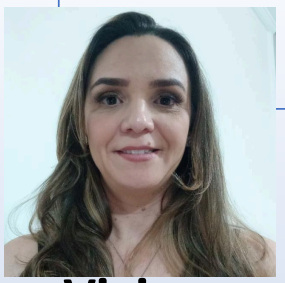
Friday, 16 August 2024

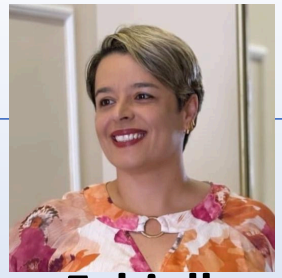
09:00-09:15 Algorithms (2): 3DVar, Static B and hybrid-EnVar (A)
09:15-10:00 Observations (3): Satellite radiance DA (A)
10:00-10:35 Algorithms (3): EDA and LETKF (A)
10:35-10:45 Break
10:45-12:00 Workflow and graphics packages (A)
12:00-13:30 Lunch
13:45-14:30 Regional MPAS-JEDI (A)
14:30-16:00 Practical session (TR)
16:00-16:10 Break
16:10-16:45 Practical session (TR)
16:45-17:00 Closing the event (A)

MONAN
Model for Ocean-laNd-Atmosphere predictioN

INPE
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

Acknowledgments


Viviane


Fabielle

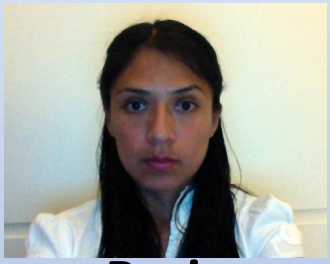

Julia


Gilson

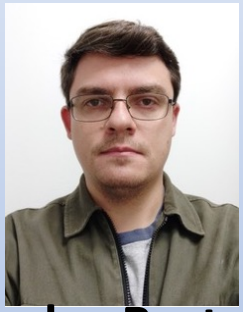

Carlos Renato


Eduardo


Enver


Rosio


Sapucci


Carlos Bastarz


Luiz Flávio

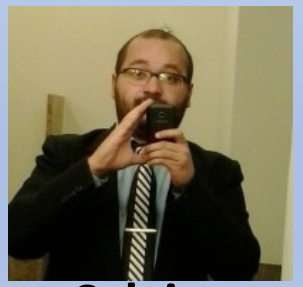

João Messias


Mario


Rose


Marcelo


P. Henrique


Sylvio


P. Kubota


Denis

MONAN
Model for Ocean-laNd-Atmosphere predictioN

Random order

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

The acronym and symbol of MONAN

Monan is a Tupi-Guarani (native people of S. America) word that means "land without evils", where they live with their ancestors and Gods, without war, starvation, or any human diseases.

Thanks for your attention!
Hope you all will have a great experience with this new modeling system.

MONAN
Model for Ocean-laNd-Atmosphere predictioN

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO