WORK VIII 2025 Eta

WORKSHOP EM MODELAGEM NUMÉRICA DE TEMPO, CLIMA E MUDANÇAS CLIMÁTICAS UTILIZANDO O MODELO ETA

# Avanços na Radiação do Modelo Eta utilizando o Esquema RRTMG

Diêgo de Andrade Campos

# RRTMG Main Features

1. **Esquema de distribuição k correlacionada** → Eficiência no cálculo da transferência radiativa;
2. **Onda curta e longa** → Trata separadamente radiação solar (SW) e terrestre (LW);
3. **Interações gás-nuvem-aerossol** → Inclui absorção, espalhamento e efeito de nuvens, GEE e aerossóis;
4. **Detalhamento espectral** → 14 bandas no SW e 16 bandas no LW;
5. **Alta precisão** → Calibrado a partir de modelos linha a linha (LBLRTM);
6. **Desempenho otimizado** → Projetado para uso em modelos climáticos e de previsão de tempo;
7. **Flexível** → Permite diferentes parametrizações de propriedades ópticas.

Meteorol Atmos Phys
DOI 10.1007/s00703-017-0500-6

CrossMark

ORIGINAL PAPER

# Eta model simulations using two radiation schemes in clear-sky conditions

**Diêgo de Andrade Campos[1] · Sin Chan Chou[1] · Christos Spyrou[2] · Júlio Cesar Santos Chagas[1] · Marcus Jorge Bottino[1]**

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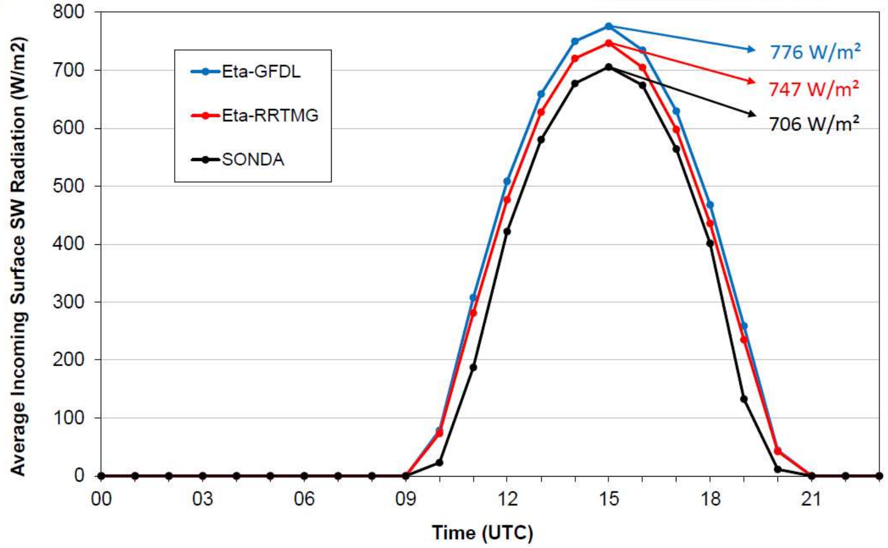
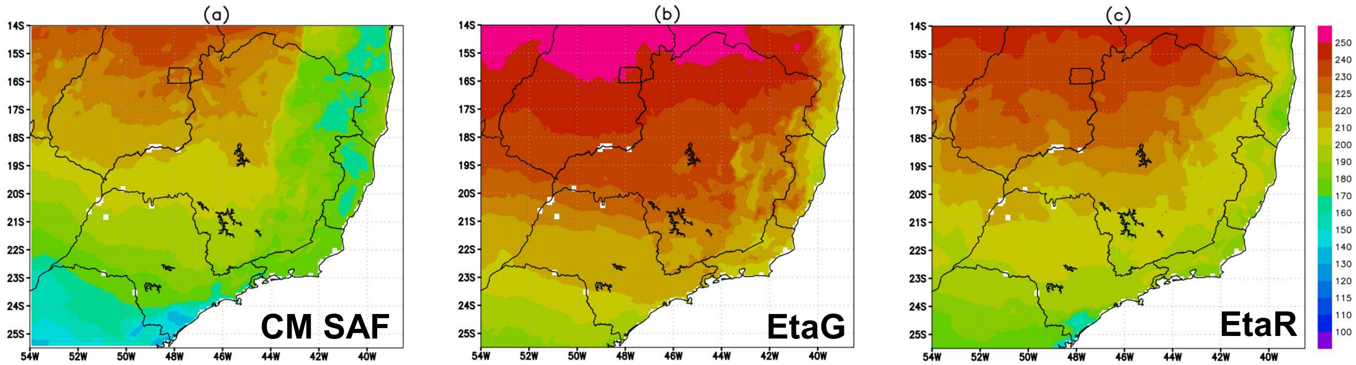
**Abstract** This work evaluates the performance of two radiation parameterization schemes in 30-day clear-sky runs of the Eta model over a region in Southeast Brazil. Two versions of the Eta model are compared: a version using the radiation scheme developed by the Geophysical Fluid Dynamics Laboratory (GFDL) and a recently developed version using the Rapid Radiative Transfer Model for GCM (RRTMG). These simulations are compared against CMSAF satellite data and surface station data. The simulation using RRTMG produced downward surface shortwave radiation fluxes closer to observations and reduced the systematic positive bias of the Eta simulation using the GFDL scheme. The 2-m temperature negative bias found in the Eta-GFDL simulations is reduced in the Eta-RRTMG simulations, which results from a larger net total radiation in the Eta-RRTMG simulations. The new version has better accuracy than the Eta using the GFDL scheme for most of the evaluated variables, particularly for clear-sky conditions.

**Keywords** Radiation scheme · Systematic bias · RRTMG · Eta model

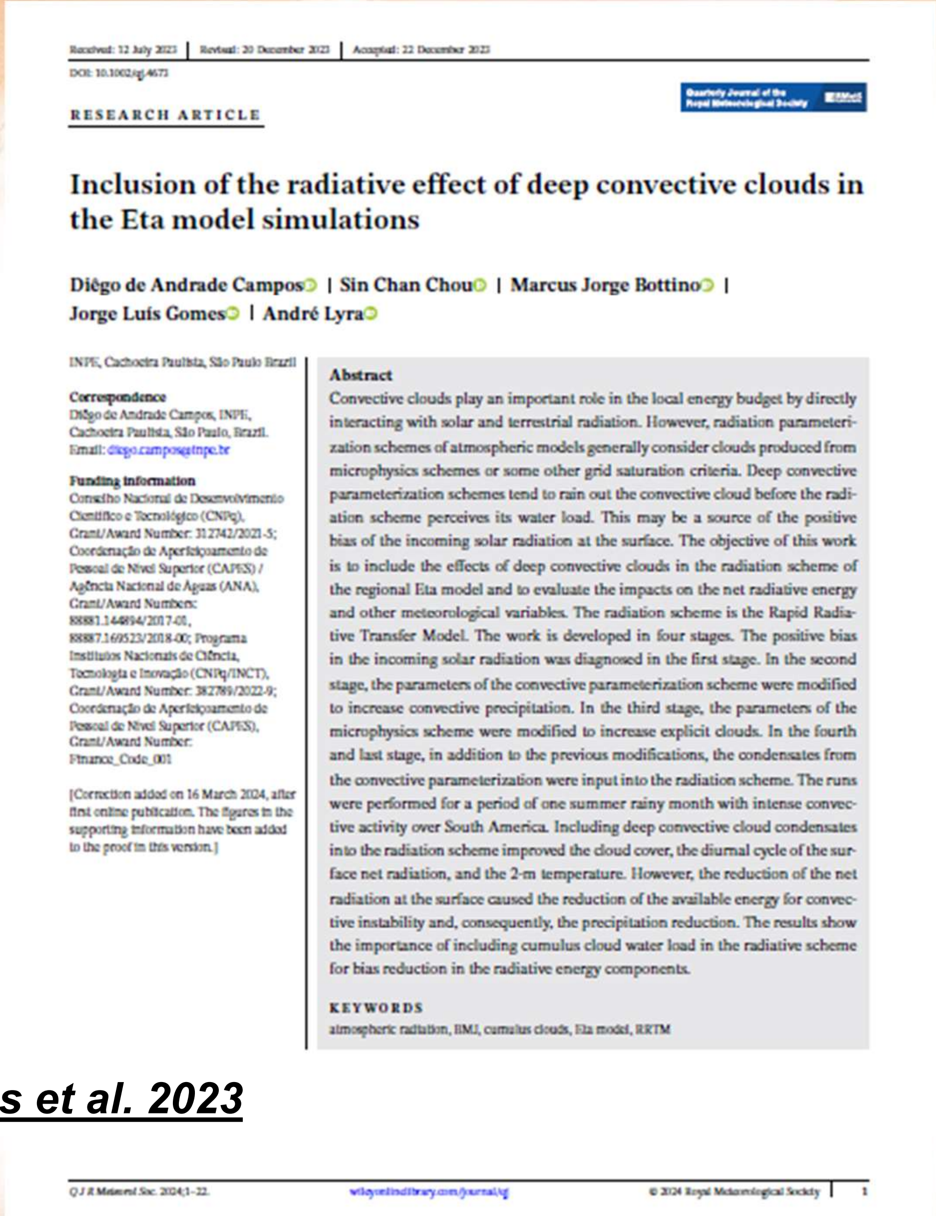
## SWrad Diurnal Cycle over clean area




## SWrad (OCIS)




***Campos et al. 2017***



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RESEARCH ARTICLE

# Inclusion of the radiative effect of deep convective clouds in the Eta model simulations

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[Correction added on 16 March 2024, after first online publication. The figures in the supporting information have been added to the proof in this version.]

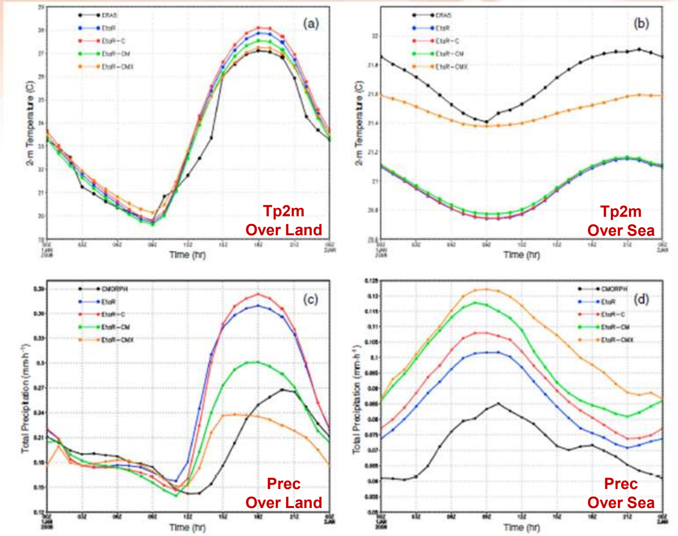
**Abstract**
Convective clouds play an important role in the local energy budget by directly interacting with solar and terrestrial radiation. However, radiation parameterization schemes of atmospheric models generally consider clouds produced from microphysics schemes or some other grid saturation criteria. Deep convective parameterization schemes tend to rain out the convective cloud before the radiation scheme perceives its water load. This may be a source of the positive bias of the incoming solar radiation at the surface. The objective of this work is to include the effects of deep convective clouds in the radiation scheme of the regional Eta model and to evaluate the impacts on the net radiative energy and other meteorological variables. The radiation scheme is the Rapid Radiative Transfer Model. The work is developed in four stages. The positive bias in the incoming solar radiation was diagnosed in the first stage. In the second stage, the parameters of the convective parameterization scheme were modified to increase convective precipitation. In the third stage, the parameters of the microphysics scheme were modified to increase explicit clouds. In the fourth and last stage, in addition to the previous modifications, the condensates from the convective parameterization were input into the radiation scheme. The runs were performed for a period of one summer rainy month with intense convective activity over South America. Including deep convective cloud condensates into the radiation scheme improved the cloud cover, the diurnal cycle of the surface net radiation, and the 2-m temperature. However, the reduction of the net radiation at the surface caused the reduction of the available energy for convective instability and, consequently, the precipitation reduction. The results show the importance of including cumulus cloud water load in the radiative scheme for bias reduction in the radiative energy components.

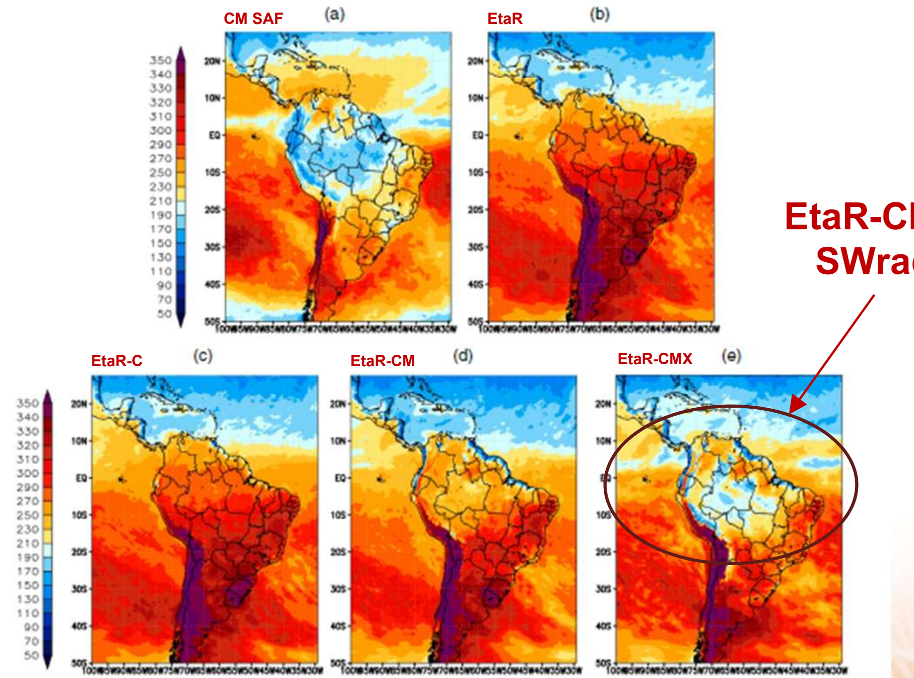
KEYWORDS
atmospheric radiation, BMJ, cumulus clouds, Eta model, RRTM





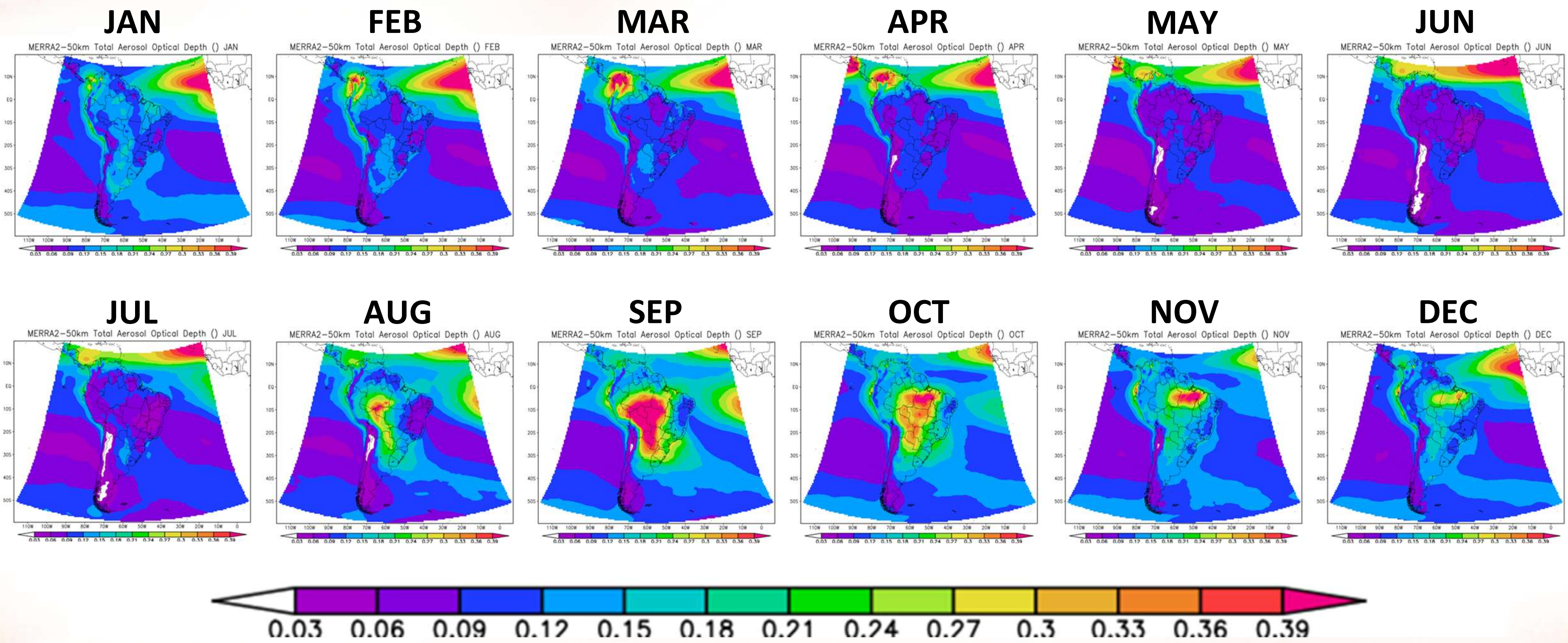
**_Campos et al. 2023_**



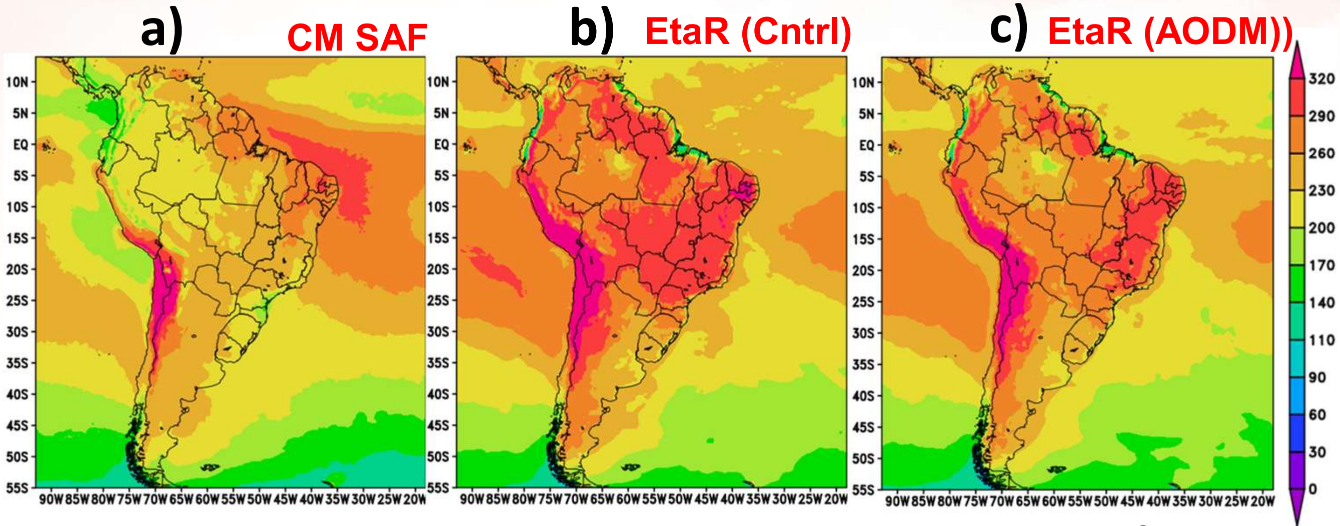

EtaR-CMX
SWrad

# Aerosol Optical Depth Input to the new version EtaR-AODM
# Source: MERRA2/NASA (Gelaro et al. 2017). Climatology 2011-2021



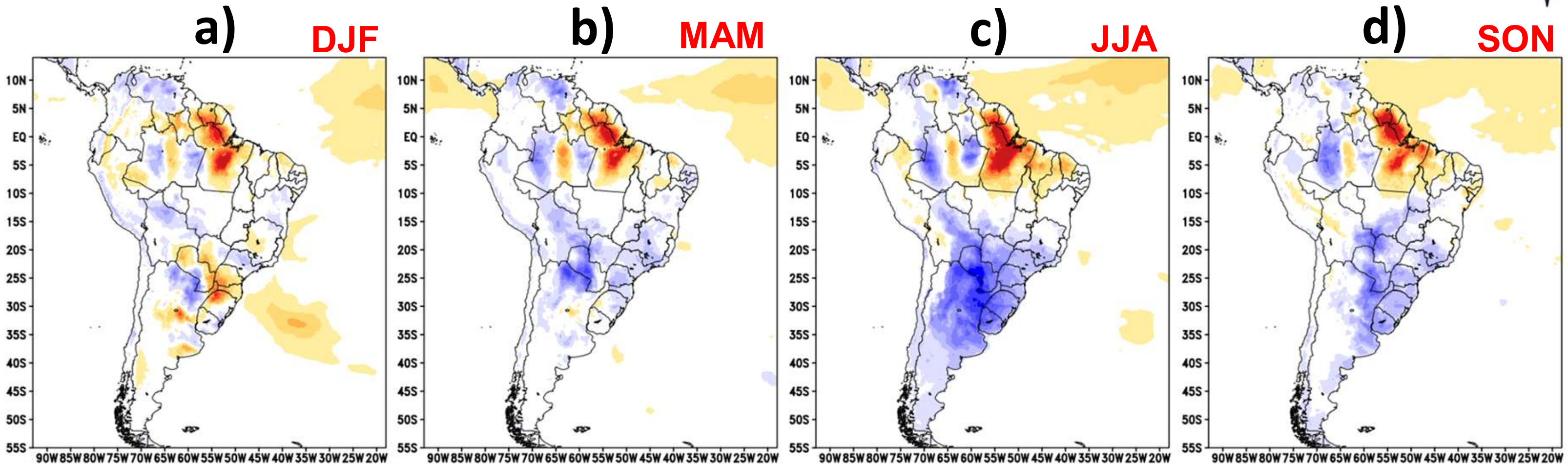
# New version EtaR-AODM (AOD input) | 5-year simulation

**Average Incoming Surface Shortwave Radiation Flux (W/m²)** from (a) CM SAF, (b) EtaR-Cntrl, and (c) EtaR-AODM. Seasonal average for SON during the 2012–2015.




**2-m Temperature (°C) Difference :**
**EtaR-AODM** minus **EtaR-Cntrl**

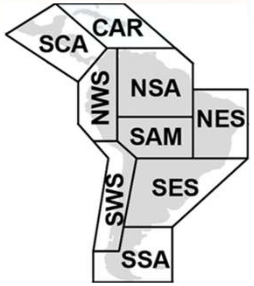
Seasonal averages for (a) DJF, (b) MAM, (c) JJA, and (d) SON during the 2012–2015.

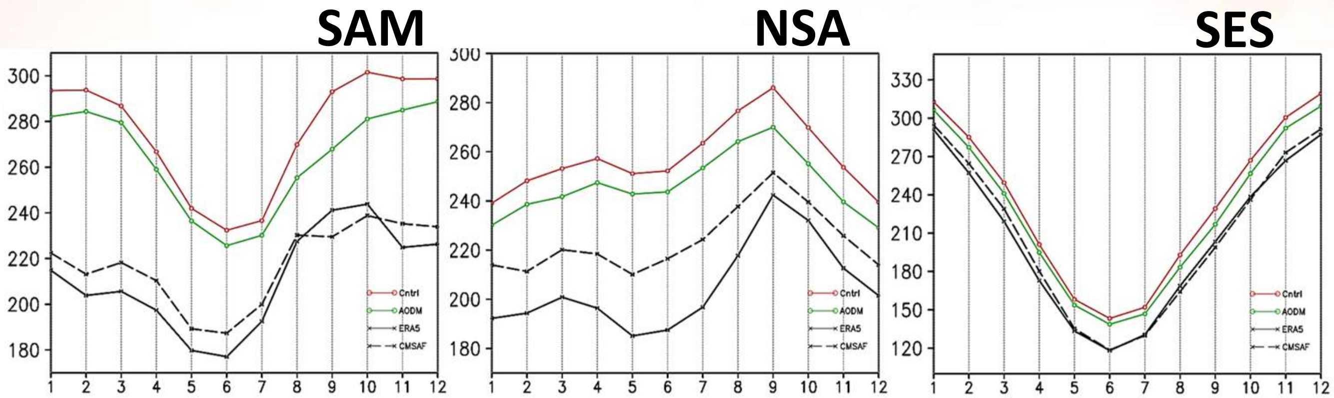



**Initial warm biases are reduced**

# New version EtaR-AODM (AOD input) | 5-year simulation

**Annual cycle of average incoming surface shortwave radiation flux (W/m²) from EtaR-Cntrl and EtaR-AODM runs compared to ERA5 and CM SAF data.** Evaluation over AR6 regions (SAM, NSA, and SES) for the 2012–2015 period.




**Statistical metrics of EtaR-Cntrl and EtaR-AODM runs for the 2012–2015 Period over all Domain.**
The improved results are in **bold**.

| VAR | OCIS (W/m²) | | PREC (mm/day) | | TP2M (°C) |
|---|---|---|---|---|---|
| OBS. | ERA5 | CMSAF | ERA5 | MSWEP | ERA5 |
| **EtaR-Cntrl (2012-2015)** | | | | | |
| BIAS | +17.24 | +15.17 | **+0.17** | **+0.73** | **+0.54** |
| MAE | +29.48 | +31.54 | +2.15 | +2.2087 | **+1.61** |
| RMSE | +40.68 | +41.07 | +3.96 | +3.93 | +2.11 |
| SCORR | 0.7413 | 0.720 | 0.510 | 0.501 | 0.9664 |
| **EtaR-AODM (2012-2015)** | | | | | |
| BIAS | **+9.45** | **+7.38** | +0.19 | +0.74 | +0.56 |
| MAE | **+27.65** | **+29.55** | **+2.14** | **+2.2057** | +1.62 |
| RMSE | **+37.27** | **+38.24** | **+3.95** | **+3.92** | **+2.09** |
| SCORR | **0.7434** | **0.723** | **0.520** | **0.512** | **0.9673** |

## AODM

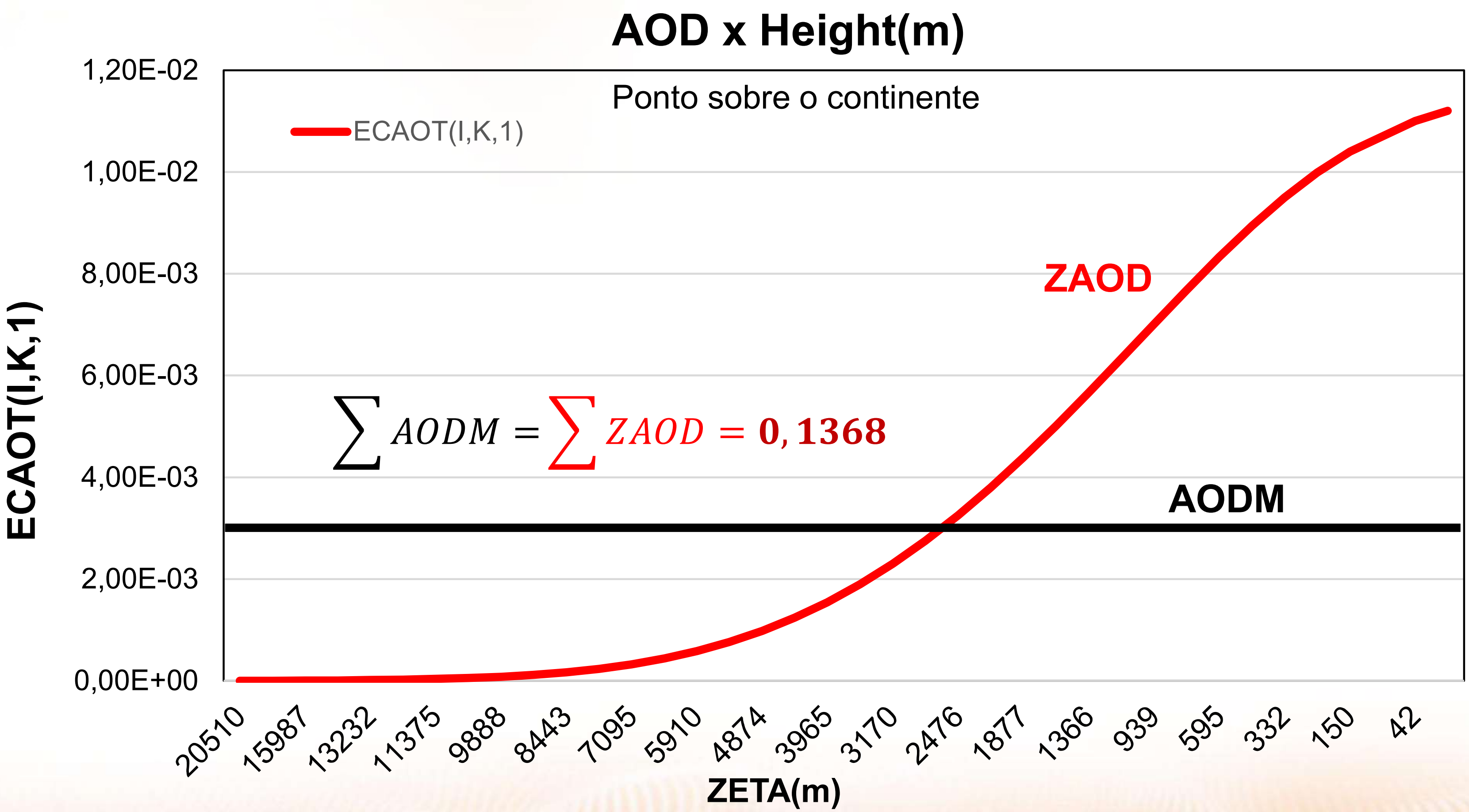
$$ECAOT(I,K,NAER) = \frac{AODRR2D(I,J)}{LMH(I,J)}$$

$\boldsymbol{LMH} = Níveis\ Eta\ (Atmosfera\ Livre)$

## ZAOD

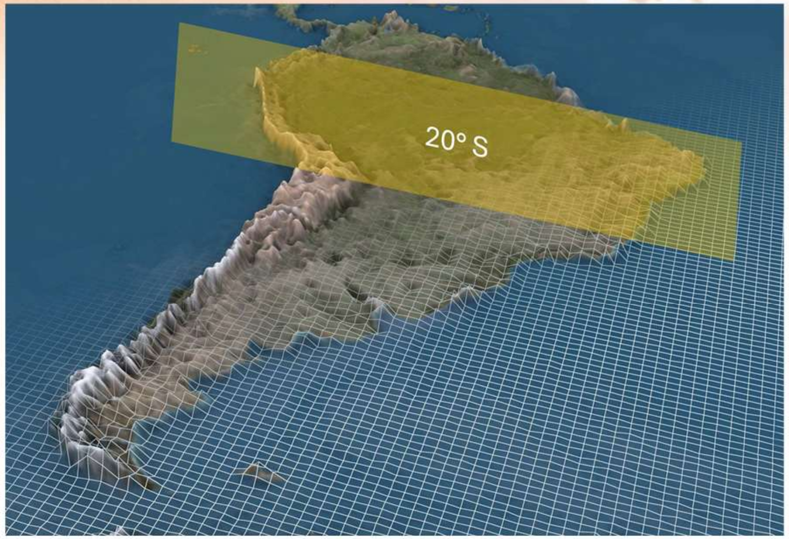
$$ECAOT(I,K,NAER) = AODRR2D(I,J) \times \frac{e^{\frac{-(Z_k - \boldsymbol{Z_{k*}})}{H}}}{\sum_{k=1}^{N} e^{\frac{-(Z_k - \boldsymbol{Z_{k*}})}{H}}}$$

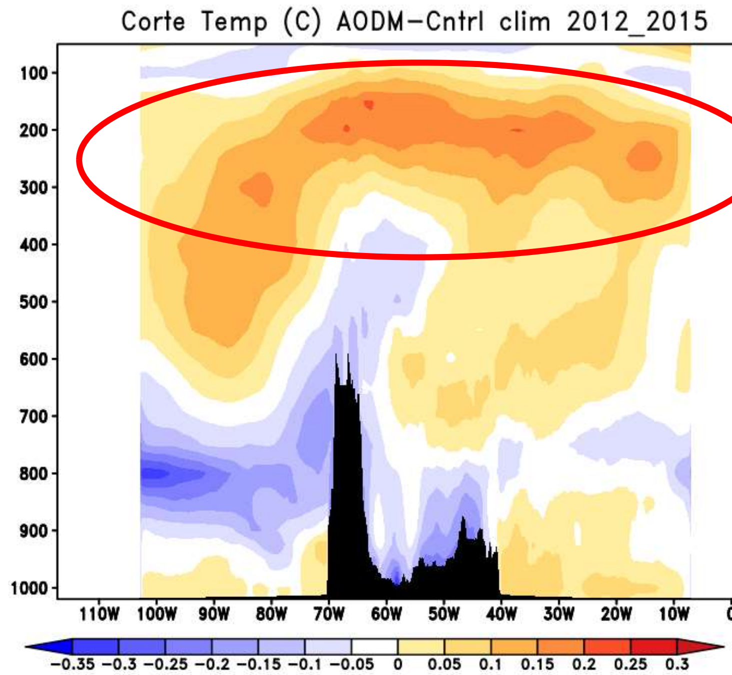
$\boldsymbol{Z_{k*}} = \boldsymbol{Z(LMH)}$

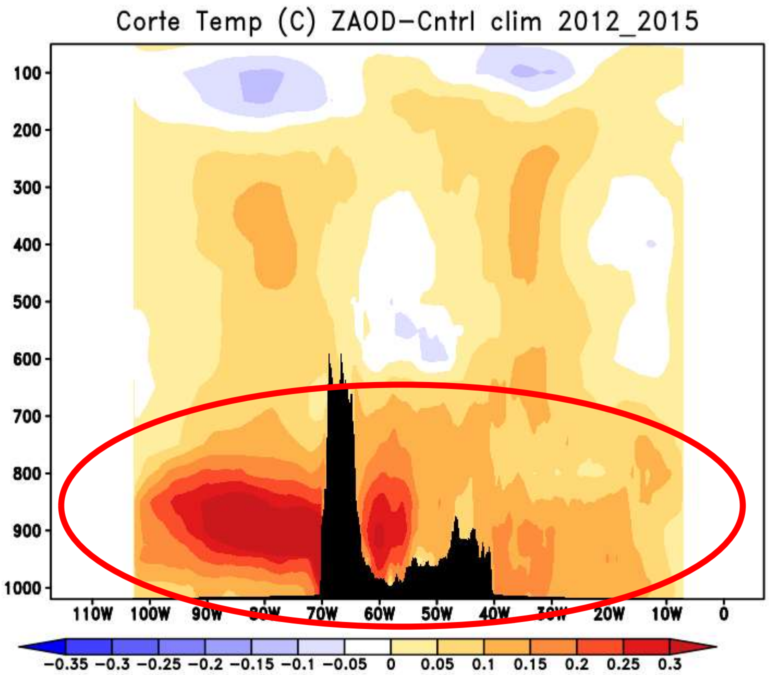


# Resultado Preliminar

**Mean Temperature Profile (°C)**
**(2012-2015)**



# Eta-RGAS Trace Gases update for CMIP6 scenarios

| YEAR | CO2 (ppm) | CH4 (ppb) | N2O (ppb) | CFC11 (ppt) | CFC12 (ppt) | HCFC22 (ppt) | CCL4 (ppt) |
|---|---|---|---|---|---|---|---|
| 1984 | 3,44008E-04 | 1,64350E-06 | 3,03528E-07 | 1,99967E-10 | 3,66799E-10 | 6,07425E-11 | 9,89400E-11 |
| 1985 | 3,45459E-04 | 1,65591E-06 | 3,04247E-07 | 2,14033E-10 | 3,83267E-10 | 6,48002E-11 | 1,00182E-10 |
| 1986 | 3,46903E-04 | 1,66879E-06 | 3,05002E-07 | 2,22340E-10 | 4,02412E-10 | 6,91396E-11 | 1,01673E-10 |
| 1987 | 3,48775E-04 | 1,68375E-06 | 3,05793E-07 | 2,33336E-10 | 4,23347E-10 | 7,39844E-11 | 1,03074E-10 |
| 1988 | 3,51276E-04 | 1,69394E-06 | 3,06624E-07 | 2,44826E-10 | 4,49323E-10 | 7,95381E-11 | 1,04169E-10 |
| 1989 | 3,52894E-04 | 1,70563E-06 | 3,07831E-07 | 2,56589E-10 | 4,68072E-10 | 8,53903E-11 | 1,05883E-10 |
| 1990 | 3,54073E-04 | 1,71740E-06 | 3,08683E-07 | 2,63085E-10 | 4,82756E-10 | 9,09836E-11 | 1,06468E-10 |
| 1991 | 3,55353E-04 | 1,72933E-06 | 3,09233E-07 | 2,67790E-10 | 4,93784E-10 | 9,64025E-11 | 1,05853E-10 |
| 1992 | 3,56229E-04 | 1,74014E-06 | 3,09725E-07 | 2,70776E-10 | 5,05868E-10 | 1,01492E-10 | 1,04983E-10 |
| 1993 | 3,56925E-04 | 1,74310E-06 | 3,10099E-07 | 2,71169E-10 | 5,11988E-10 | 1,05417E-10 | 1,04323E-10 |
| 1994 | 3,58254E-04 | 1,74862E-06 | 3,10808E-07 | 2,69628E-10 | 5,18214E-10 | 1,10944E-10 | 1,03570E-10 |
| 1995 | 3,60239E-04 | 1,75523E-06 | 3,11279E-07 | 2,68104E-10 | 5,24657E-10 | 1,16048E-10 | 1,02889E-10 |
| 1996 | 3,62005E-04 | 1,75719E-06 | 3,12298E-07 | 2,66756E-10 | 5,31408E-10 | 1,24729E-10 | 1,02311E-10 |
| 1997 | 3,63252E-04 | 1,76150E-06 | 3,13183E-07 | 2,65292E-10 | 5,34963E-10 | 1,27377E-10 | 1,01242E-10 |
| 1998 | 3,65933E-04 | 1,77029E-06 | 3,13907E-07 | 2,63884E-10 | 5,37667E-10 | 1,34273E-10 | 1,00316E-10 |
| 1999 | 3,67845E-04 | 1,77820E-06 | 3,14709E-07 | 2,62546E-10 | 5,40143E-10 | 1,38681E-10 | 9,93309E-11 |
| 2000 | 3,69125E-04 | 1,77801E-06 | 3,15759E-07 | 2,61170E-10 | 5,42383E-10 | 1,43461E-10 | 9,82720E-11 |
| 2001 | 3,70673E-04 | 1,77653E-06 | 3,16493E-07 | 2,59550E-10 | 5,43195E-10 | 1,49257E-10 | 9,73580E-11 |
| 2002 | 3,72835E-04 | 1,77896E-06 | 3,17101E-07 | 2,57669E-10 | 5,43656E-10 | 1,54425E-10 | 9,63430E-11 |
| 2003 | 3,75411E-04 | 1,78359E-06 | 3,17730E-07 | 2,55413E-10 | 5,43351E-10 | 1,58996E-10 | 9,53454E-11 |

Source: Meinshausen et al. 2017)

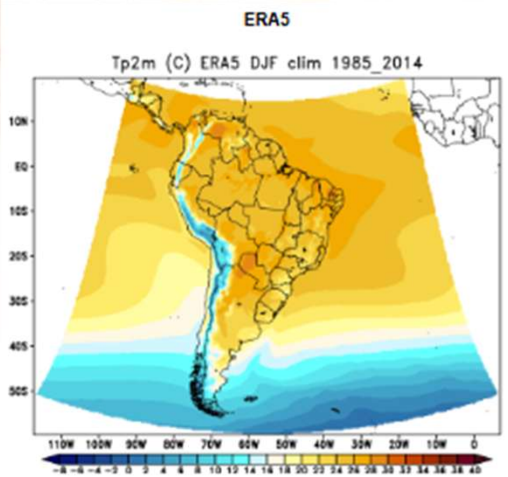
Fixed Values

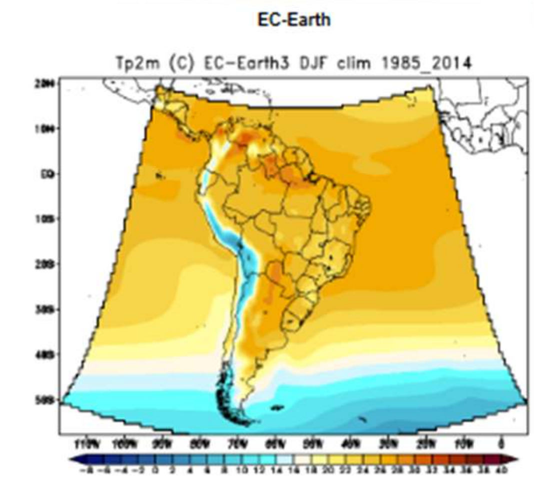
```
!-------------------------------------------
!     RRCO2(I,K) = 3.550000E-04
!     RRN2O(I,K) = 3.110000E-07
!     RRCH4(I,K) = 1.714000E-06
!     RRCFC11(I,K) = 0.300000E-9
!     RRCFC12(I,K) = 0.500000E-9
!     RRCFC22(I,K) = 0.200000Ee-9
!     RRCCL4(I,K)  = 0.000000E-0
!-------------------------------------------
```

Updated Values (1984)

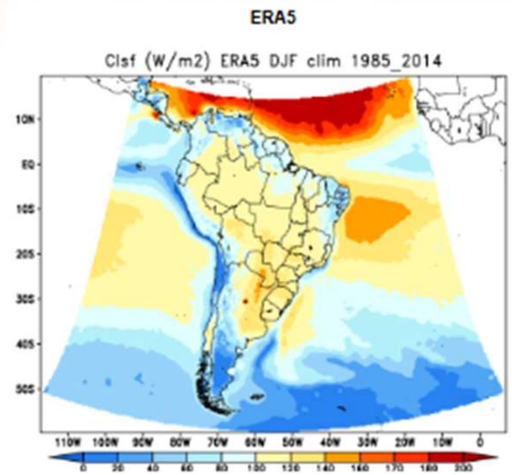
```
!-------------------------------------------
!     RRCO2(I,K) = 3.4400800E-04
!     RRN2O(I,K) = 3.0352800E-07
!     RRCH4(I,K) = 1.6435000E-06
!     RRCFC11(I,K) = 1.9996700E-10
!     RRCFC12(I,K) = 3.6679901E-10
!     RRCFC22(I,K) = 6.0742501E-11
!     RRCCL4(I,K)  = 9.8940002E-11
!-------------------------------------------
```

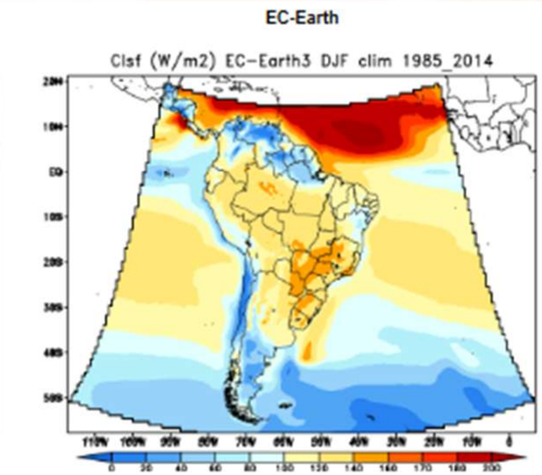
## 2m-Temperature (°C)

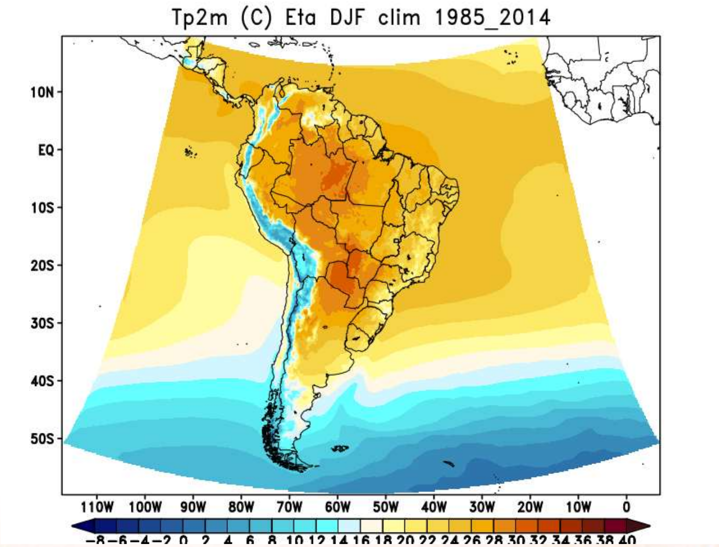



## Surface Latent Heat Flux (W/m²)

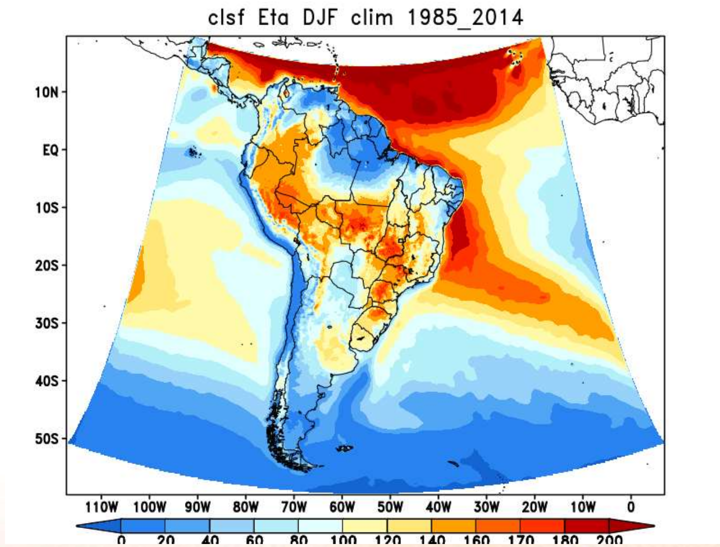


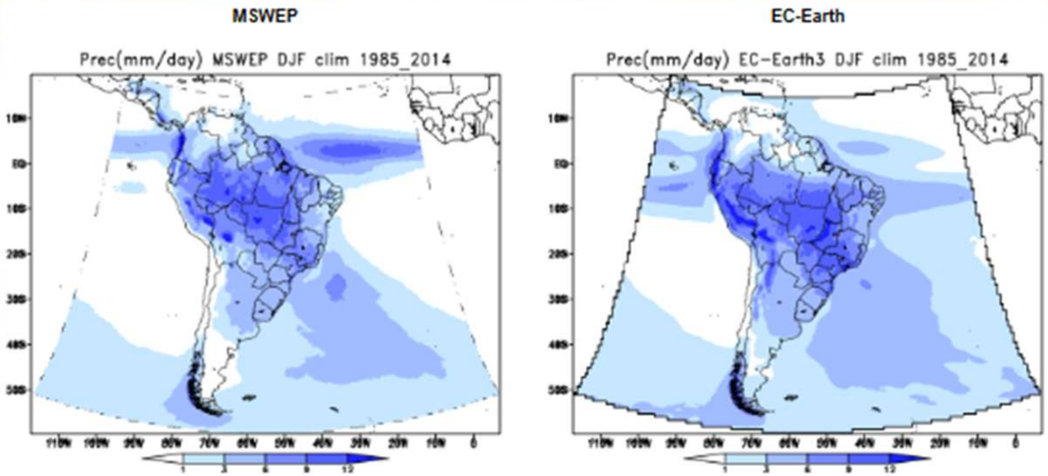




**1985-2014**

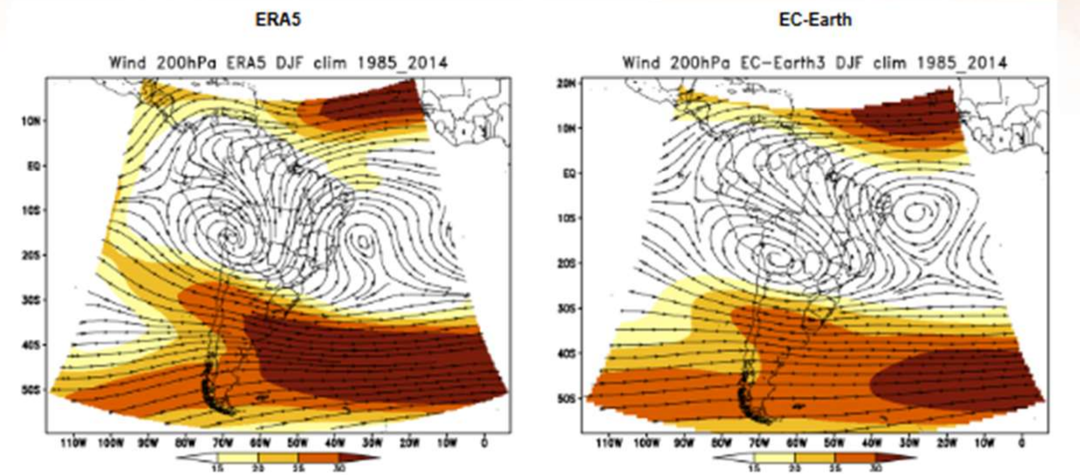
**Eta-RGAS**

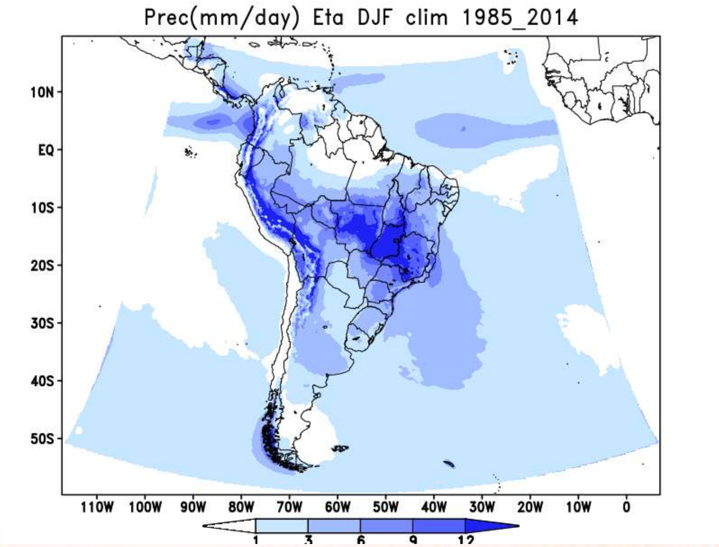


## Total Precipitation (mm/day)



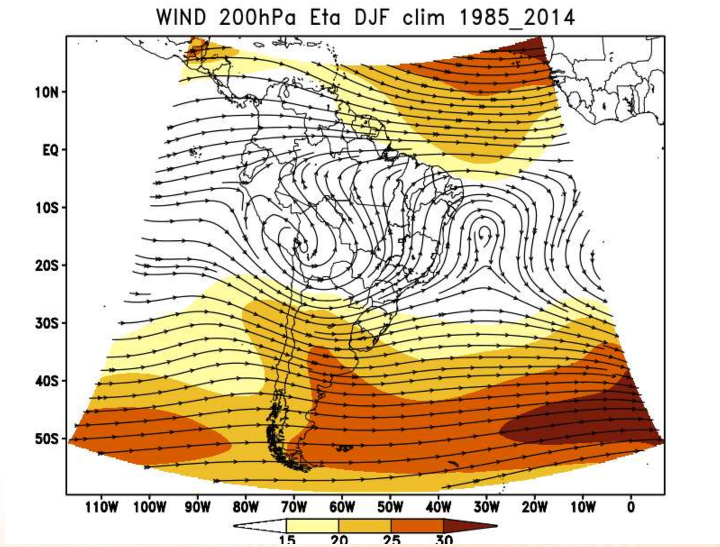

## Wind 200 hPa (m/s)



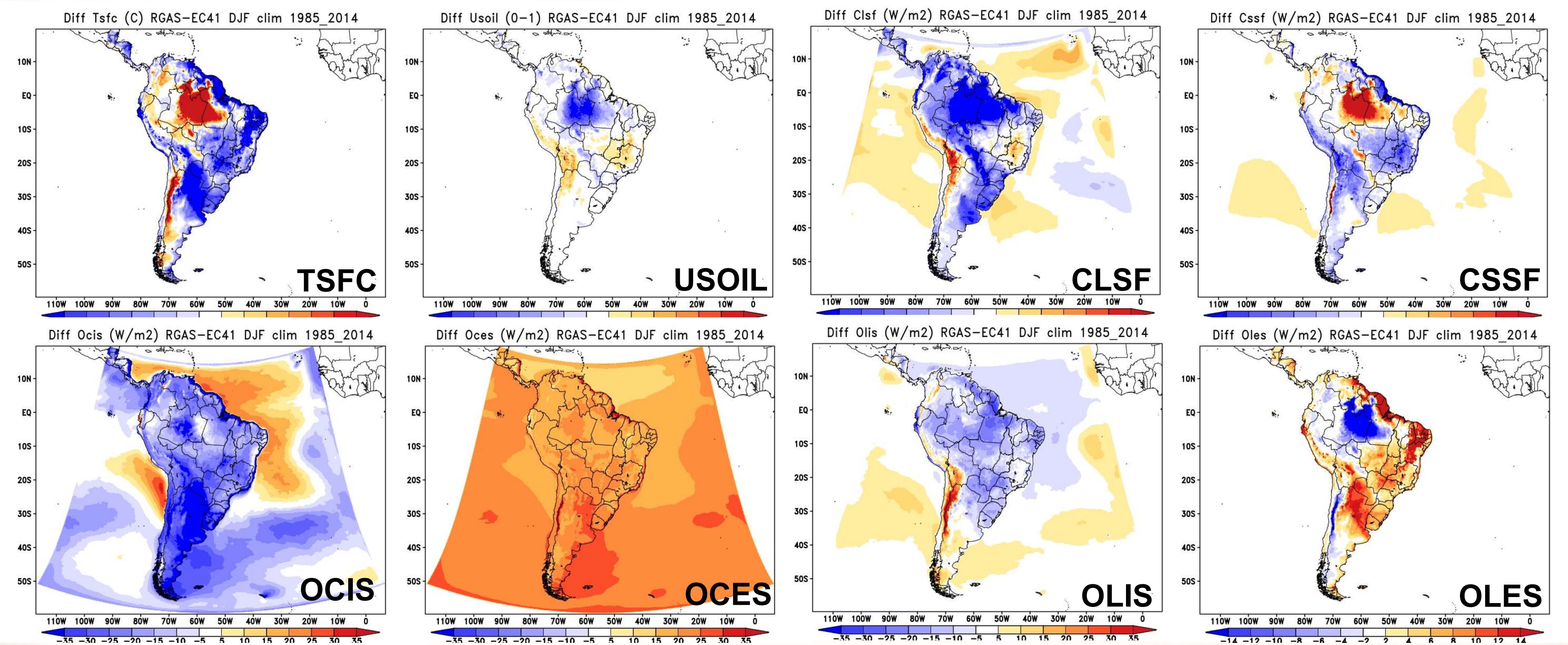




# 1985-2014

**Eta-RGAS**



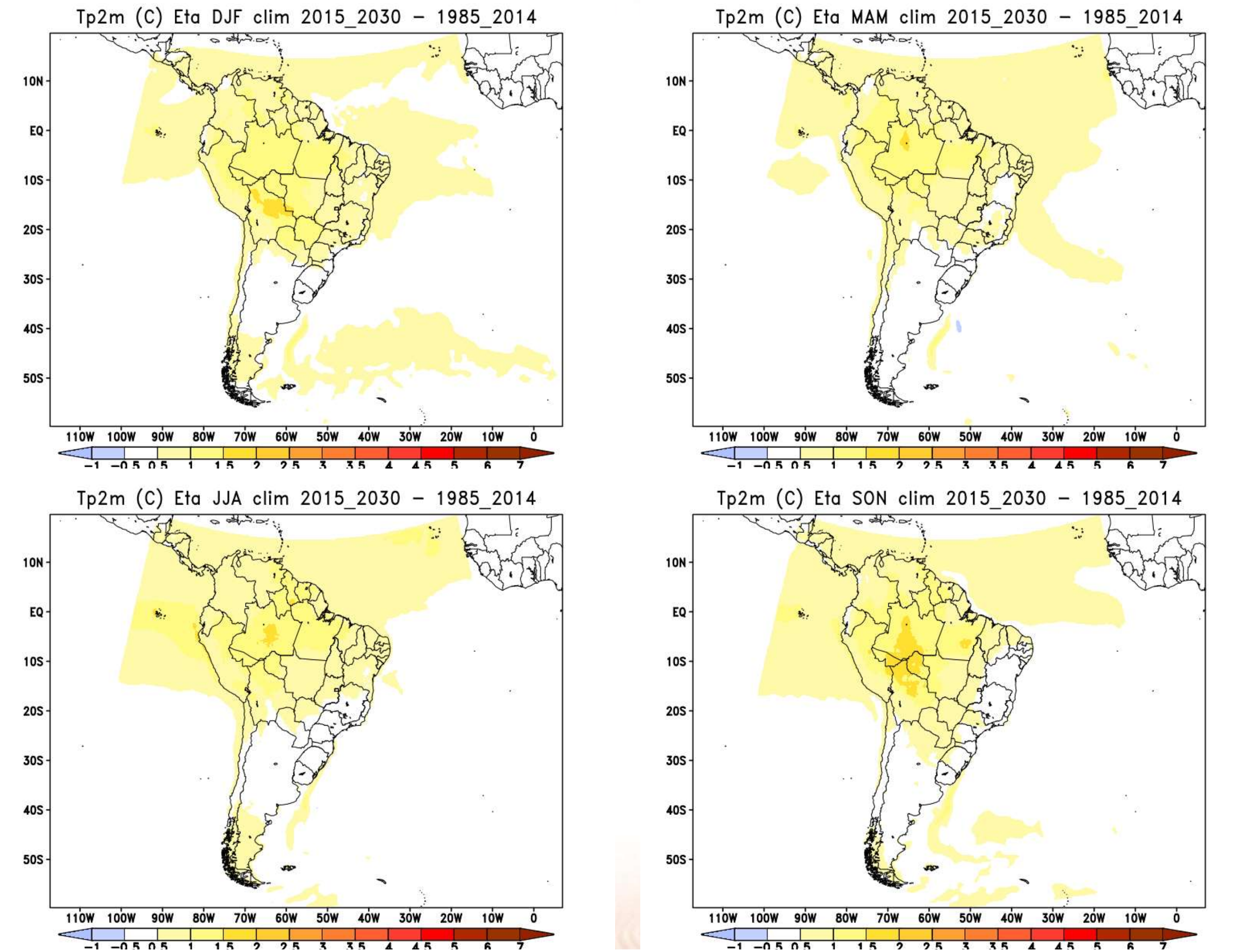
# 30-Years Difference Eta-RGAS/Eta-GFDL (1985-2014)



# Eta-RGAS Projected Temperature Change (SSP585 x Historical)

**2m-Temperature (°C)**

Aumento observado de
temperatura a 2 metros
Entre aproximadamente
0.5 e 1.5 graus.



# Eta-RRTMG future work

- Elevação do TOA de 25 hPa para 50 e 1 hPa (Climate Change Version);
- Aprimorar o efeito radiação-aerossóis na vertical;
- Atualização do Ozônio Climatológico;
- RRTMG na versão “Global Eta Framework” (GEF);
- Versão unificada incluindo aerossóis, rampa atualizada de GEE, elevação do TOA, atualização do ozônio e efeito radiação-cumulus profunda.

# OBRIGADO!!