The WGNE Aerosol project:
Evaluating the impact of aerosols on Numerical Weather and Subseasonal Prediction

Ariane Frassoni[1], Angela Benedetti[2], Frederic Vitart[2], François Engelbrecht[1], Georg Grell[3] and Paul Makar[3]

1-WGNE members
2-WWRP/S2S members
3-GAW Scientific Advisory Group Modelling Applications: SAG-APPs

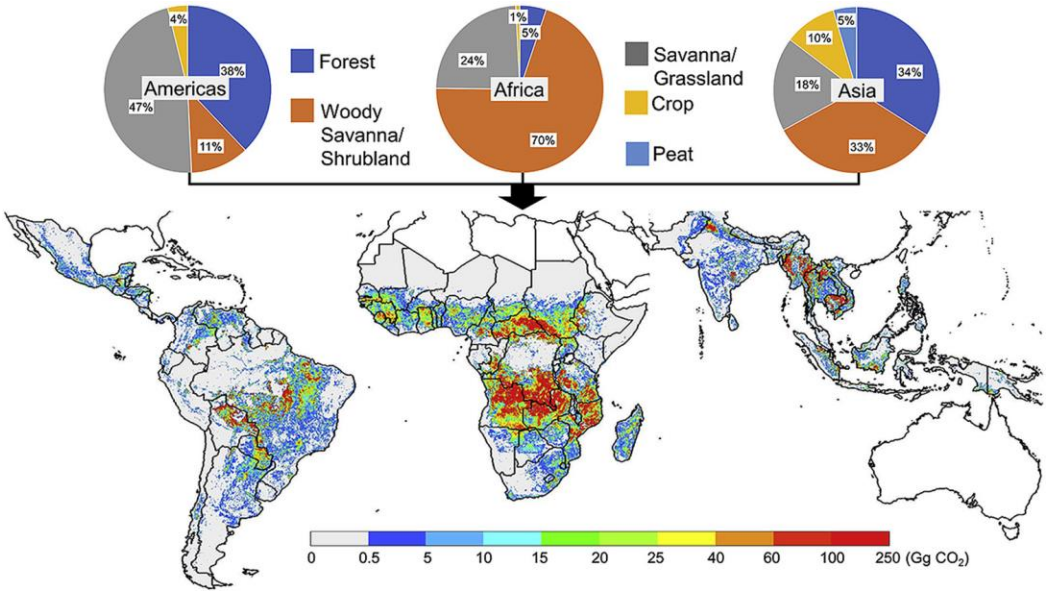
Thanks to J. Flemming, A. Baklanov, J. G. Mattos, G. Araújo, L. Sapucci, D. Moreira, A. Molod, C. Spyrou and many others

Ariane.frassoni@inpe.br

37th WGNE Session
NCAR, Boulder, CO, USA
08 Nov 2022

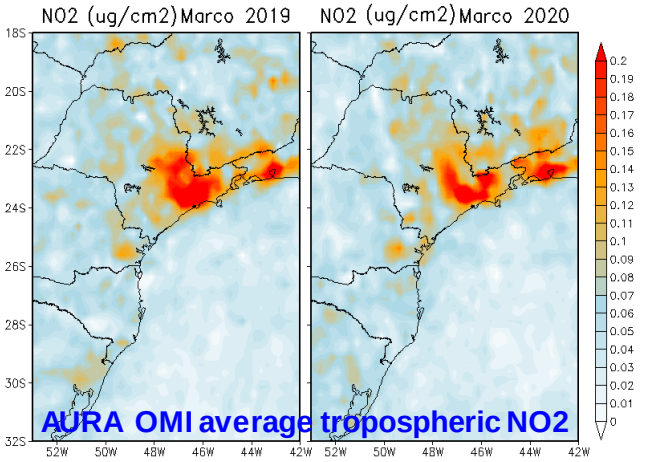
Motivation

Biomass burning emissions in tropical continents



Shi et al., 2020

NO2 in Southeaster Brazil before and during the 1st month of COVID-19 lockdown



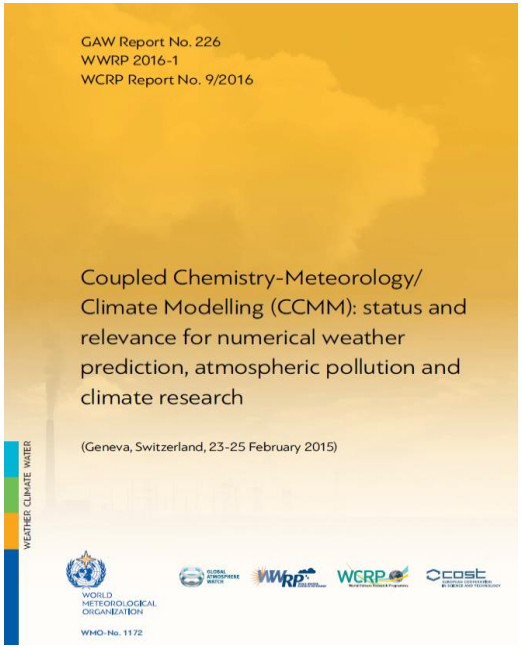
Frassoni, 2020

NOV 2022 SHARM EL-SHEIKH COP27

WMO OMM

Coupled Chemistry-Meteorology Models (CCMM) for NWP, AQ and Climate applications: *key scientific questions*

- **What are the advantages of integrating meteorological and chemical/aerosol processes in coupled models?**
- **How important are the two-way feedbacks and chains of feedbacks for meteorology, climate, and air quality simulations?**
- **What are the effects of climate/meteorology on the abundance and properties (chemical, microphysical, and radiative) of aerosols on urban/regional/global scales?**
- **What is our current understanding of** cloud-aerosol interactions and **how well are radiative feedbacks represented in NWP/climate models?**
- **What is the relative importance of the direct** and indirect **effects of aerosol as well as of gas-aerosol interactions for different applications (e.g., for NWP, air quality, climate)?**
- **What are the key uncertainties associated with model predictions of feedback effects?**
- How to realize chemical data assimilation in integrated models for improving NWP and air quality simulations?
- How the simulated feedbacks can be verified with available observations/datasets? What are the requirements for observations from the three modelling communities?



https://library.wmo.int/doc_num.php?explnum_id=7938

IN BOX
INSIGHTS and INNOVATIONS

Key Issues for Seamless Integrated Chemistry–Meteorology Modeling

Alexander Baklanov, Dominik Brunner, Gregory Carmichael, Johannes Flemming, Saulo Freitas, Michael Gauss, Øystein Hov, Rohit Mathur, K. Heinke Schlünzen, Christian Seigneur, and Bernhard Vogel

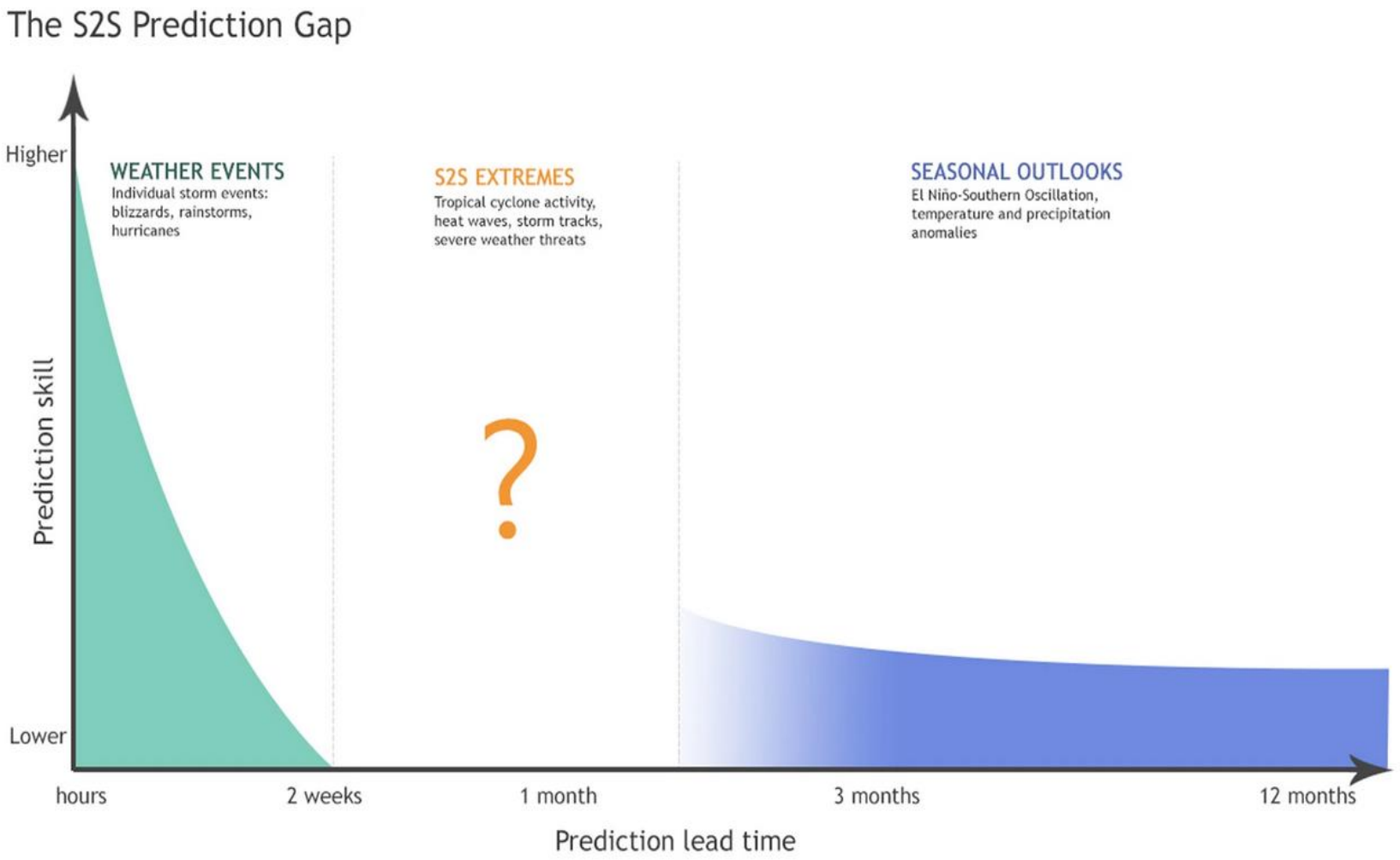
WMO OMM

Courtesy: A. Baklanov

BAMS Paper:
https://doi.org/10.1175/BAMS-D-15-00166.1

Motivation

From: Progress in subseasonal to seasonal prediction through a joint weather and climate community effort

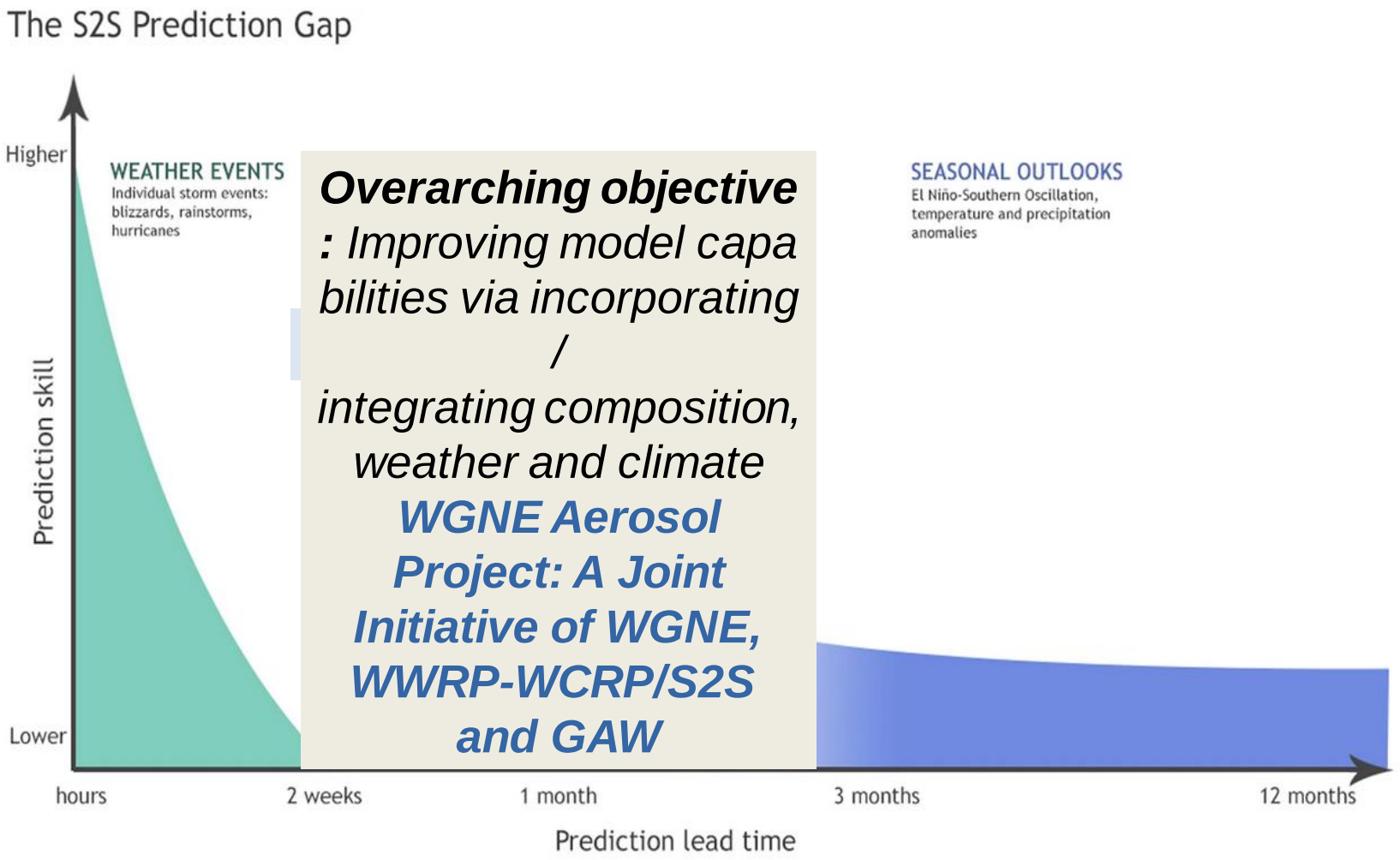


Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

Mariotti, A., Ruti, P.M. & Rixen, M. *npj Clim Atmos Sci* **1,** 4 (2018). https://doi.org/10.1038/s41612-018-0014-z

Motivation

From: Progress in subseasonal to seasonal prediction through a joint weather and climate community effort



Overarching objective *: Improving model capabilities via incorporating / integrating composition, weather and climate*

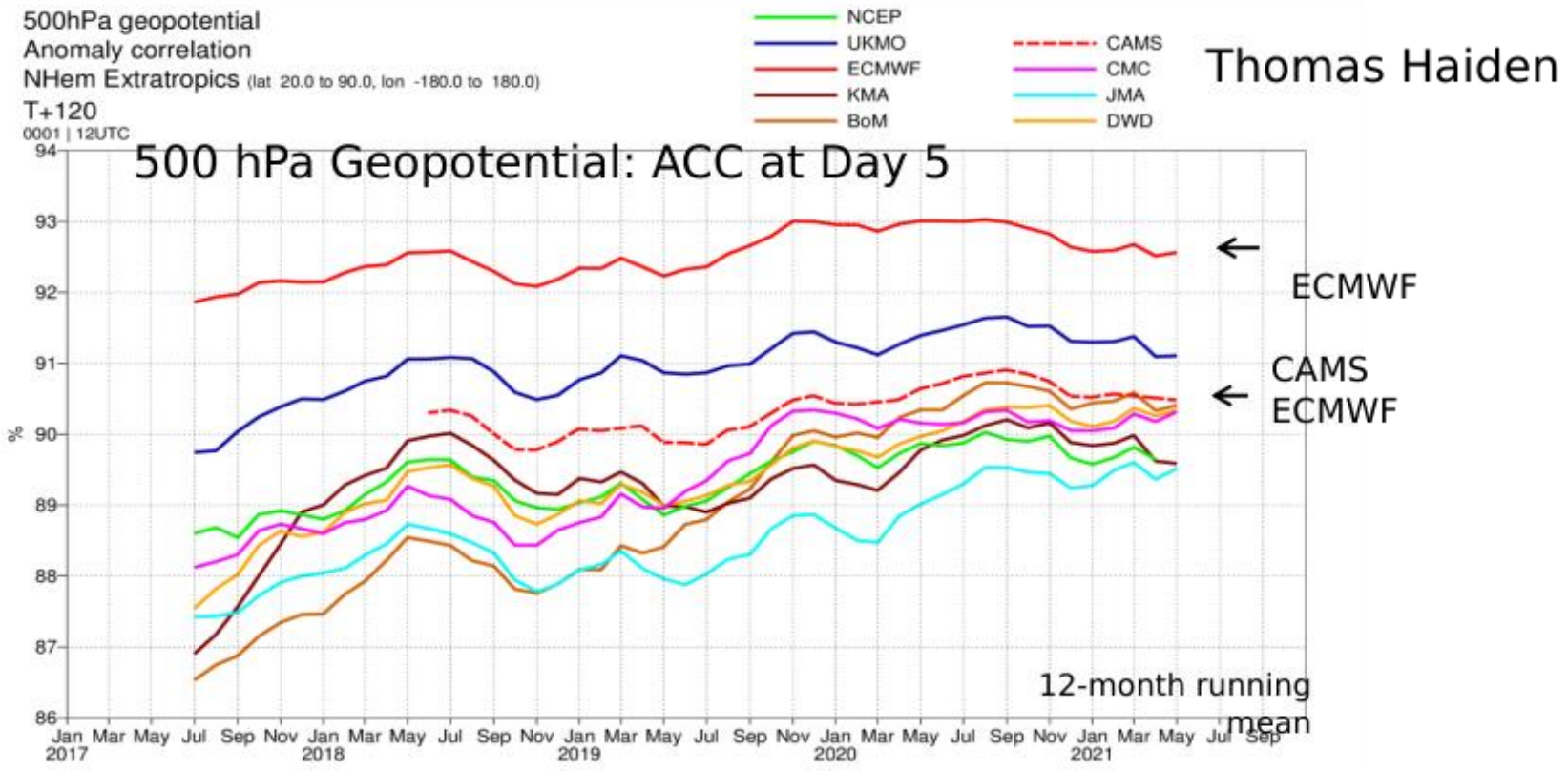
WGNE Aerosol Project: A Joint Initiative of WGNE, WWRP-WCRP/S2S and GAW

Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

Mariotti, A., Ruti, P.M. & Rixen, M. *npj Clim Atmos Sci* **1,** 4 (2018). https://doi.org/10.1038/s41612-018-0014-z

Motivation

IFS-CAMS config vs other NWP centres

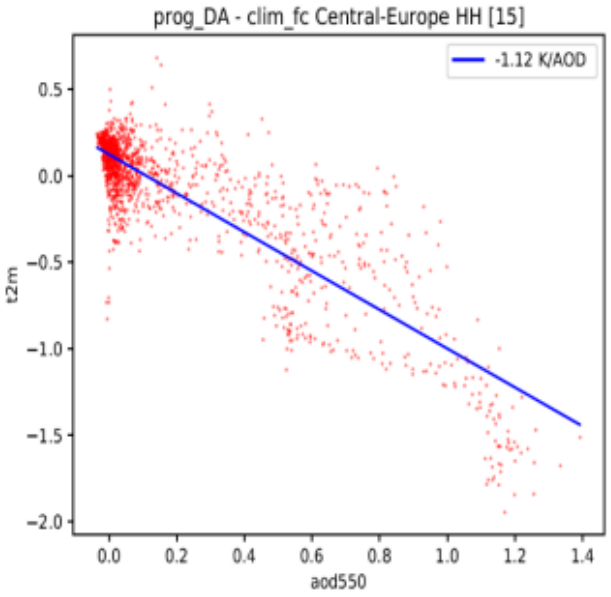


Courtesy: Flemming et al., 2022

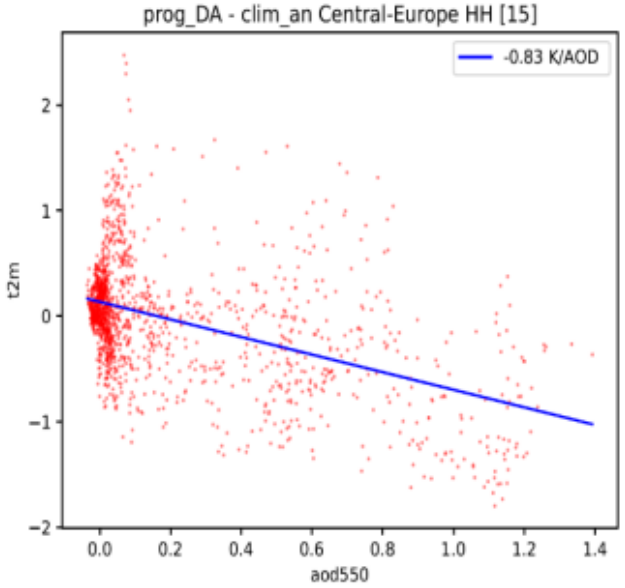
Motivation

T2m impact (prog-clim) vs AOD anomaly

14-18.3.22
15 UTC Forecast



CNTR-FC



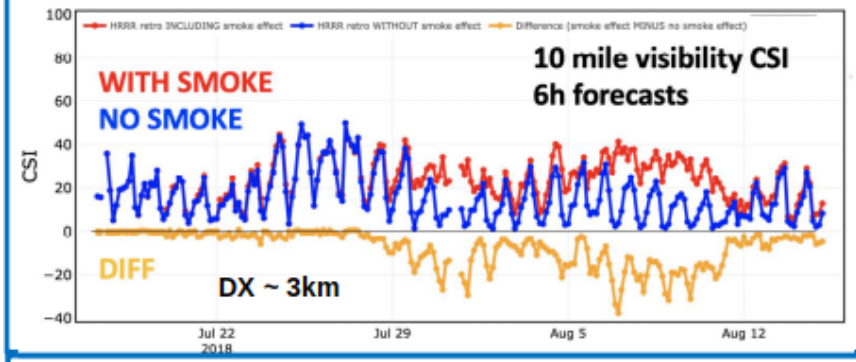
CNR-ANA

Central Europe:
-1.0 K day time
2mT cooling per
AOD unit anomaly

Courtesy: Flemming et al., 2022

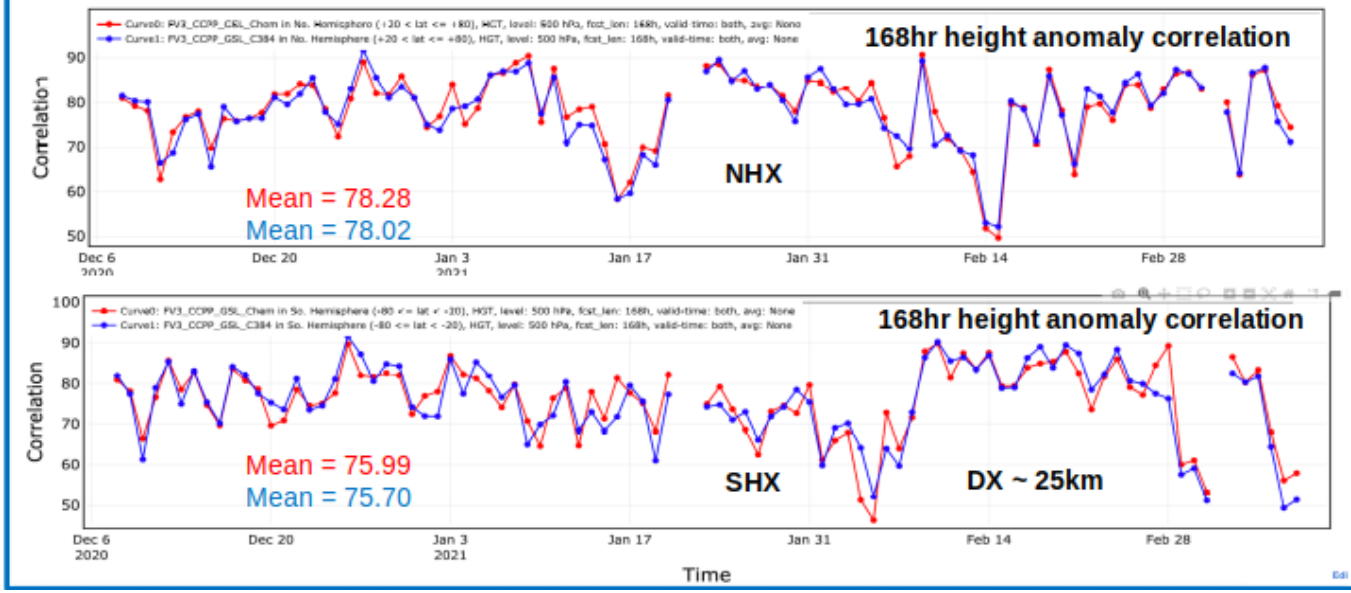
Motivation

NOAA - Lessons learned with WGNE I



Storm scale short range RAP/HRRR-Smoke (future RRFS)

Shows some significant improvements in storm-scale metrics (T2m, visibility) even with extremely simple 2 variable approach



Medium range forecasting with FV3GFS

Test of bulk aerosol impacts on radiation – slight positive impact appears apparent in ACC scores, 19 variables

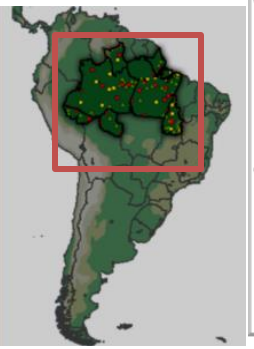
With feedback

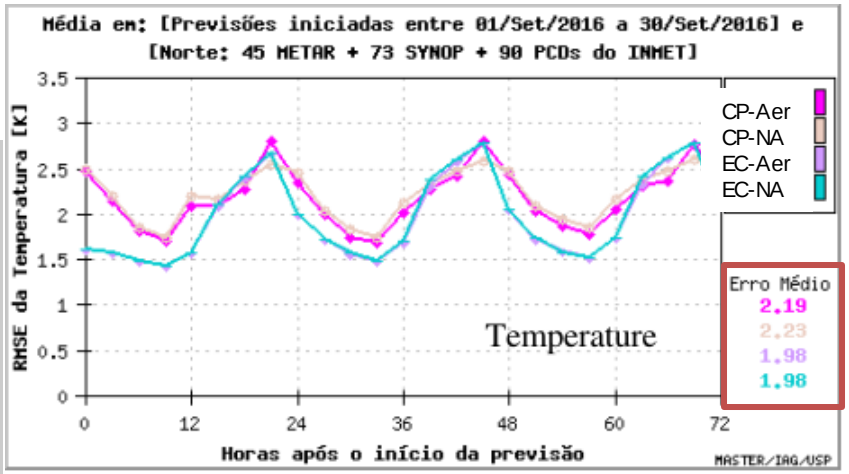
No feedback

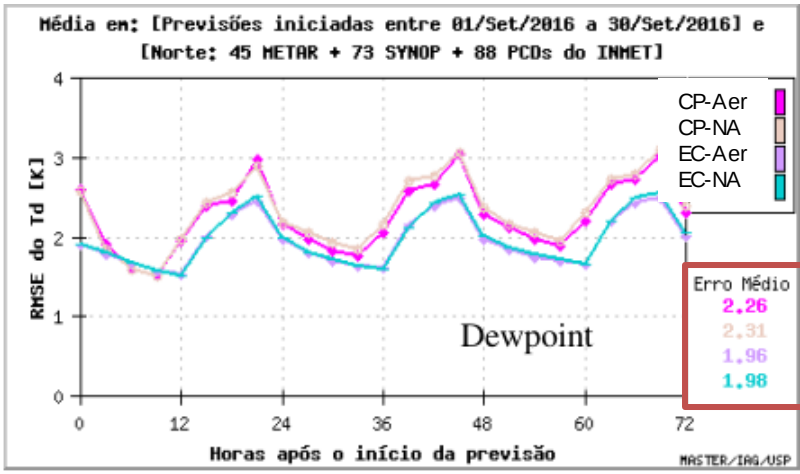
Courtesy: Grell et al., 2021

Motivation

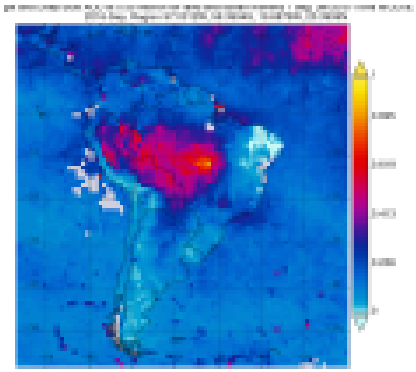
RMSE – Northern Brazil 09/2016

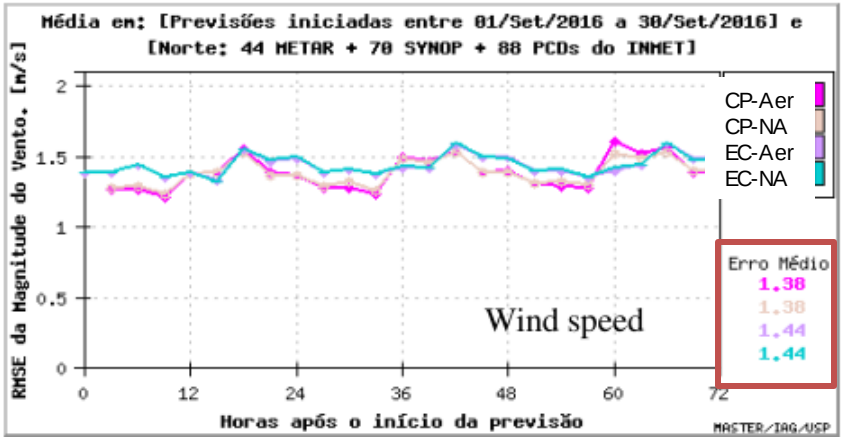






09/2016 Mean AOD - NASA





S2S Protocol

S2S Re-forecast Experiments

- Minimum 5-member ensemble
- At least 32-day long simulations from 00:00 UTC
- Time resolution: 6 hours
- Climatological aerosols vs prognostic aerosols (prescribed obs emissions for BBS)
- Initialized by own analysis/re-analysis

- **Experiment 1: Dust**
  Starting dates 1st April / **1st May** / 1st Jun 2003-2019

- **Experiment 2: Biomass Burning**
  Starting dates 1st Aug / **1st Sep** / 1st Oct 2003-2019

- **Experiment 3 (optional): Pollution in Asia**
  Starting dates 1st Dec / **1st Jan** / 1st Feb 2003-2019

Progress

S2S - Status of data delivery

Participants	Status	Delivery	Contact
ECMWF	Completed	Will send more data	A. Benedetti, F. Vitart
NOAA	Completed	Completed	G. Grell, S. Sun
NASA	Completed	Completed	A. Molod, Z. Li
ECC	Completed	Completed	P. Makar, J. Chan
CMA	Completed	In progress	J. Yao, T. Wu
JMA	-	-	Y. Takaya
KMA	In progress	-	Beomcheol Shin

Regional experiment

- Finalizing the analysis of results

- Preparing report and paper

Progress

Forecast verification

Regional	Air Quality/optical properties
RMSE	Time series – F x O
Bias	Bias
Contingency table scores	
Scorecards	

S2S - Under determinist assessment

S2S	Air Quality/optical properties
Bias of the ens mean	Time series – F x O
Correlation bet. ens mean and obs anomalies	Bias
MSSS	
Standard deviation ratio	
CRPS	
Scorecards	

Contribution from JWGFVR

Progress

Forecast verification

- T2m hindcasts of models have been evaluated using determinist metrics

- Metrics have been computed considering the start dates of **September** of each model, i.e., **Biomass Burning** is active in the Americas and Africa
  - *Extensive savanna/grassland burning in the Americas woody savanna/shrubland fires in Africajointly led to peak CO_2 emissions in August–September (Shi et al., 2020)*

- For the deterministic assessment, bias of predicted and reference temperature anomalies at each grid point were selected to measure accuracy

- The deterministic assessment was performed by computing the ensemble monthly average of all available members for each model

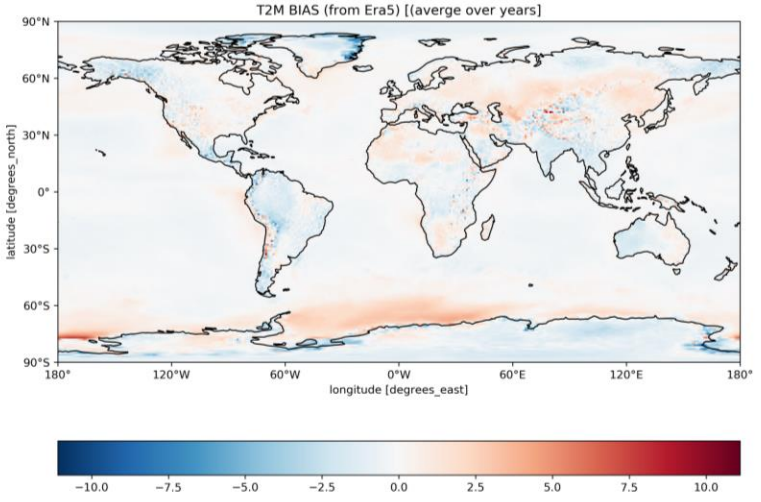
Preliminary results – S2S timescale

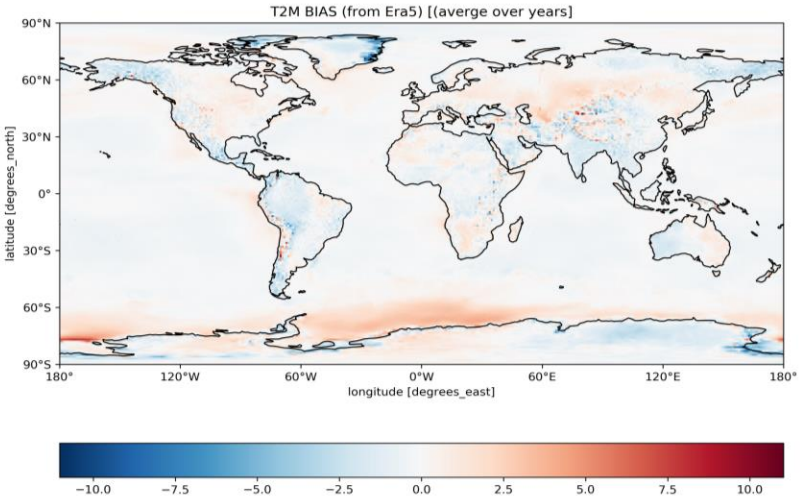
Mean bias

Interactive aerosols

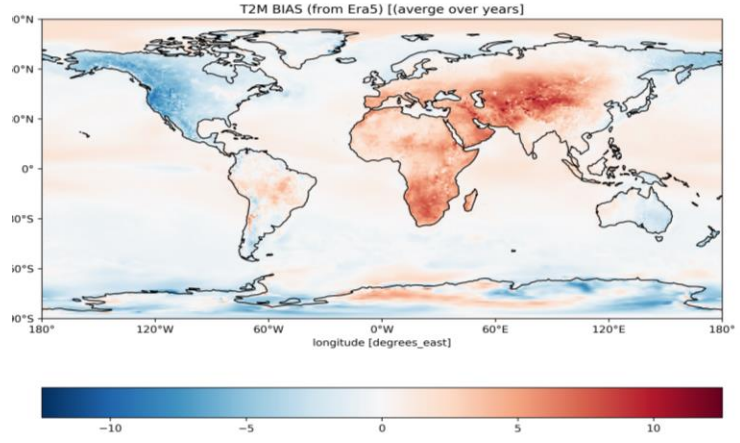
Climatological aerosols

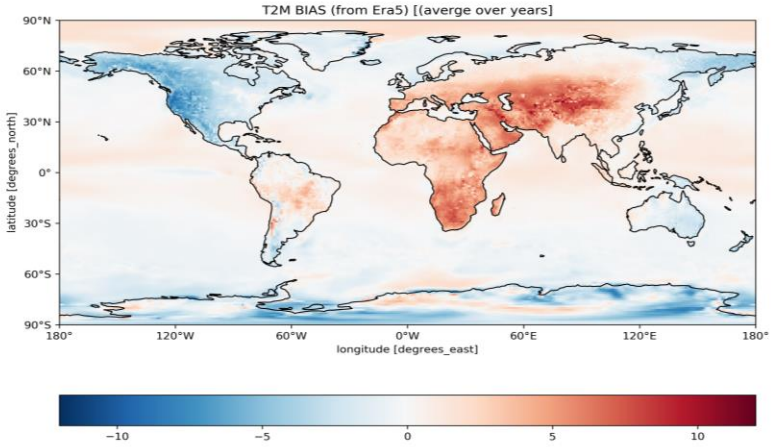
ECMWF





NASA





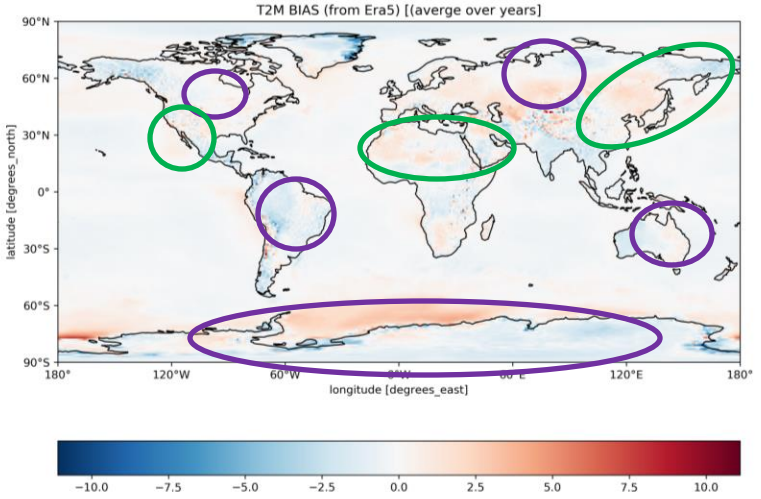
Preliminary results – S2S timescale

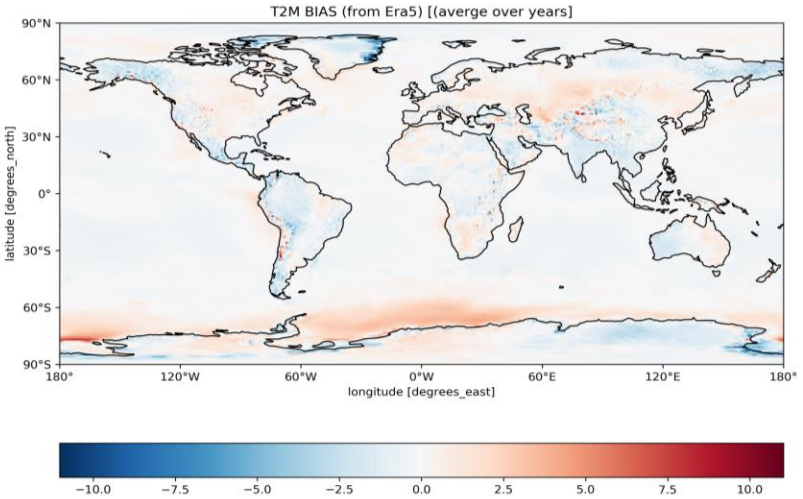
Mean bias

Interactive aerosols

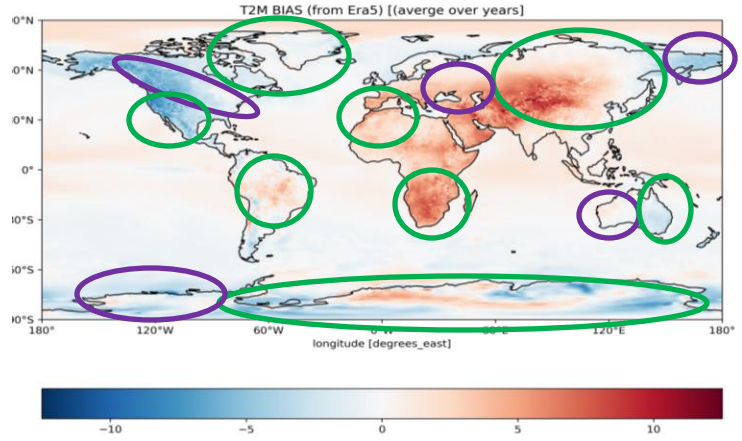
Climatological aerosols

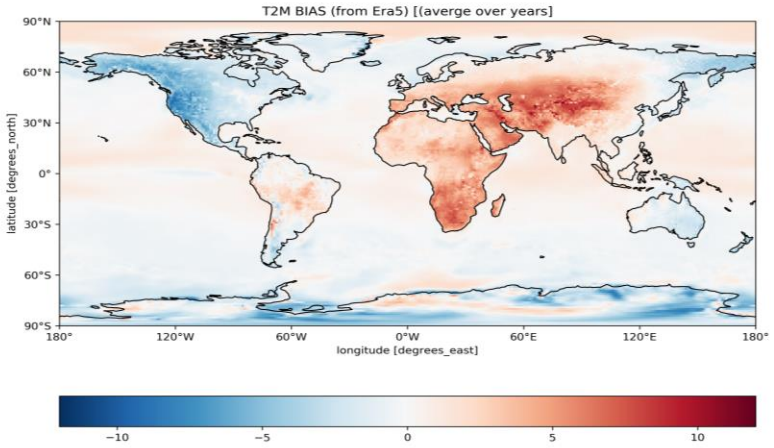
ECMWF





NASA



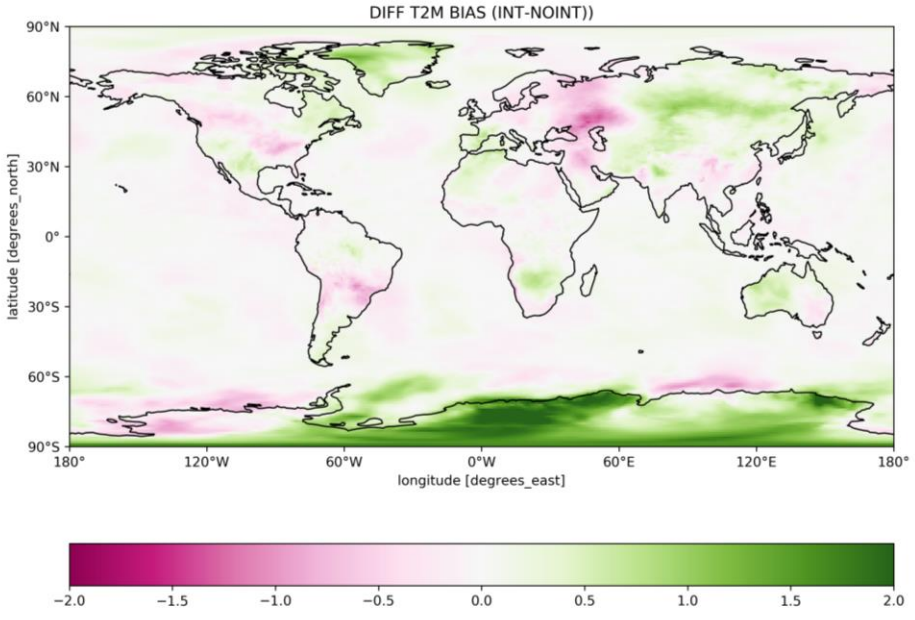


Improvement Degradation

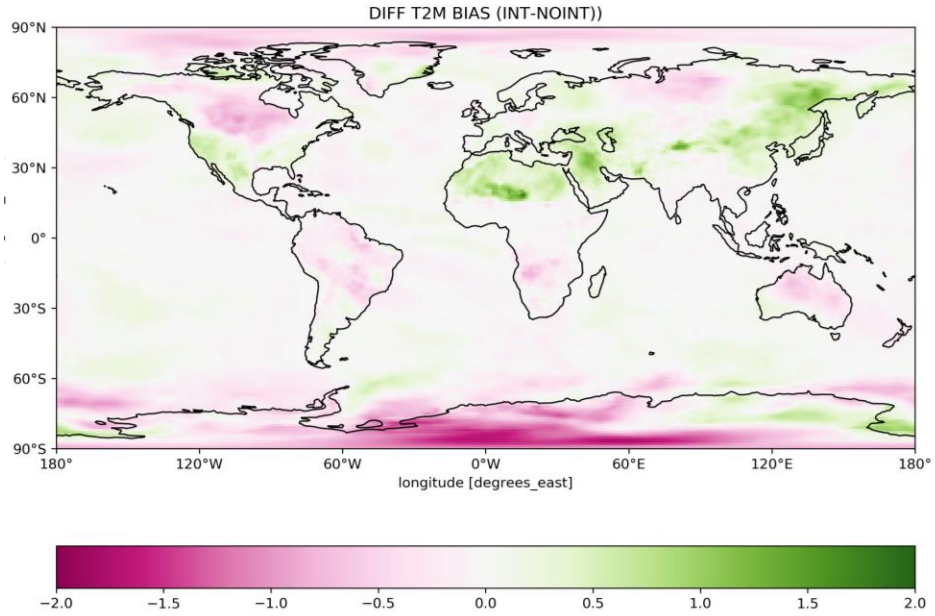
Preliminary results – S2S timescale

Bias differences: INT – NOINT

NASA



ECMWF



Improvement **Degradation**

Next steps

- Complete the analysis of meteorological variables for NWP and S2S (compute deterministic assessment of weekly anomalies)
- Apply probabilistic metrics to assess S2S forecasts
- Assessment of aerosol properties/air quality variables skill
- Schedule a meeting with modeling centres
  on the beginning of December – present preliminary results
- Journal - special edition - publish NWP and S2S together
- Prepare and submit a funding proposal - open call in Brazil (FAPESP)

Acknowledgements

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Thanks for your attention!