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

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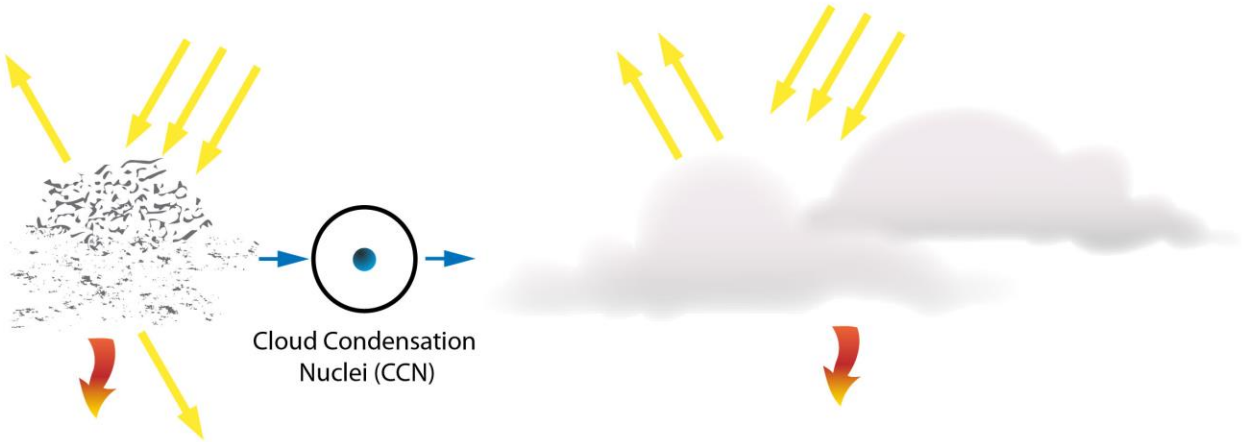
Ariane.frassoni@inpe.br

WGNE36 Meeting
On-line
01 November 2021

Aerosols as climate forcing

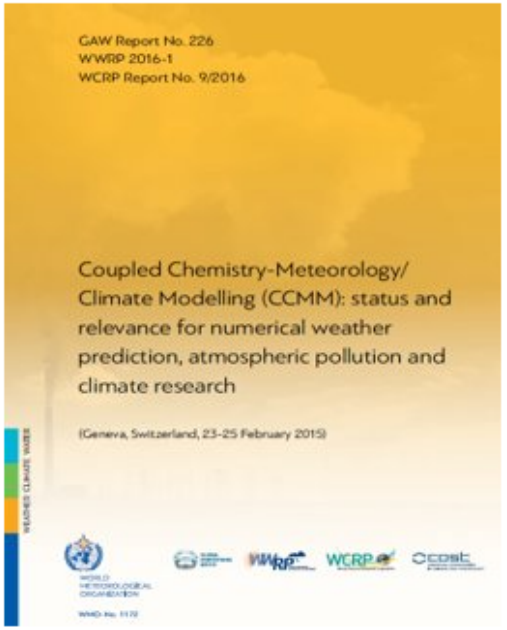


Aerosols scatter and/or absorb the incoming solar radiation, directly affecting the planet's energy balance.

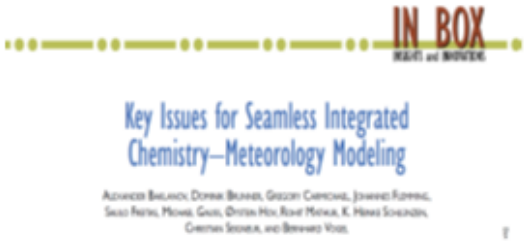
Aerosols, by acting as CCNs affect the cloud properties, thus indirectly affecting the planet's energy balance.

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



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

WMO OMM

Courtesy: A. Baklanov

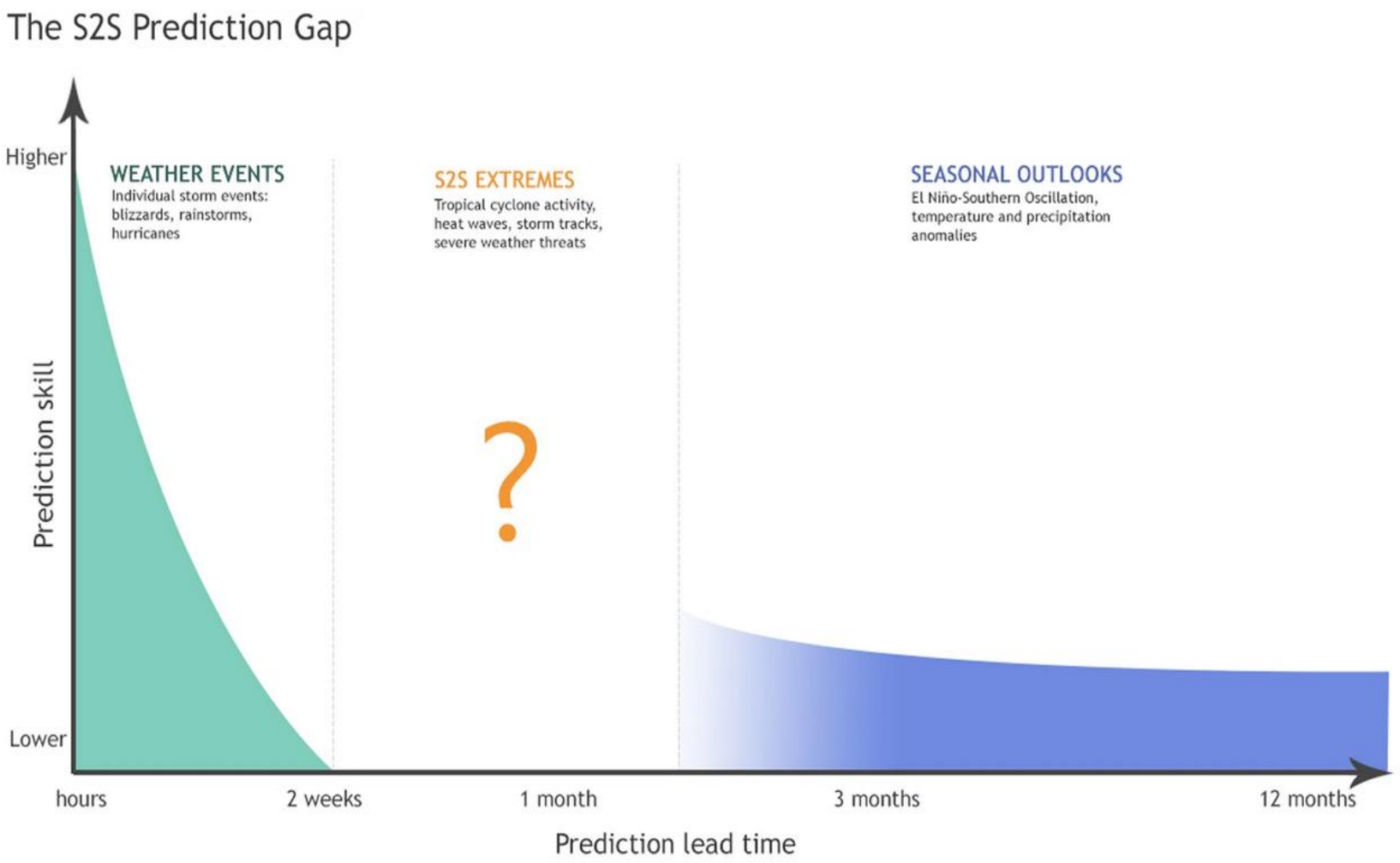
WGNE Aerosol project goals

- Understand the role of aerosols for the predictability of the atmosphere at short, medium-range and subseasonal time scales
- Identify and quantify the **predictability of aerosols**, especially on *subseasonal* time scale and the value of aerosol forecasts for applications
- Understand the level of complexity needed to represent positive effects of atmospheric composition and to provide skillful meterorological and aerosol forecasts

Update the **knowledge about the current capabilities** of modelling groups to simulate the impact of aerosols on short-range and subseasonal time scales

Evaluating the Impact of Aerosols on NWP and Subseasonal Prediction

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

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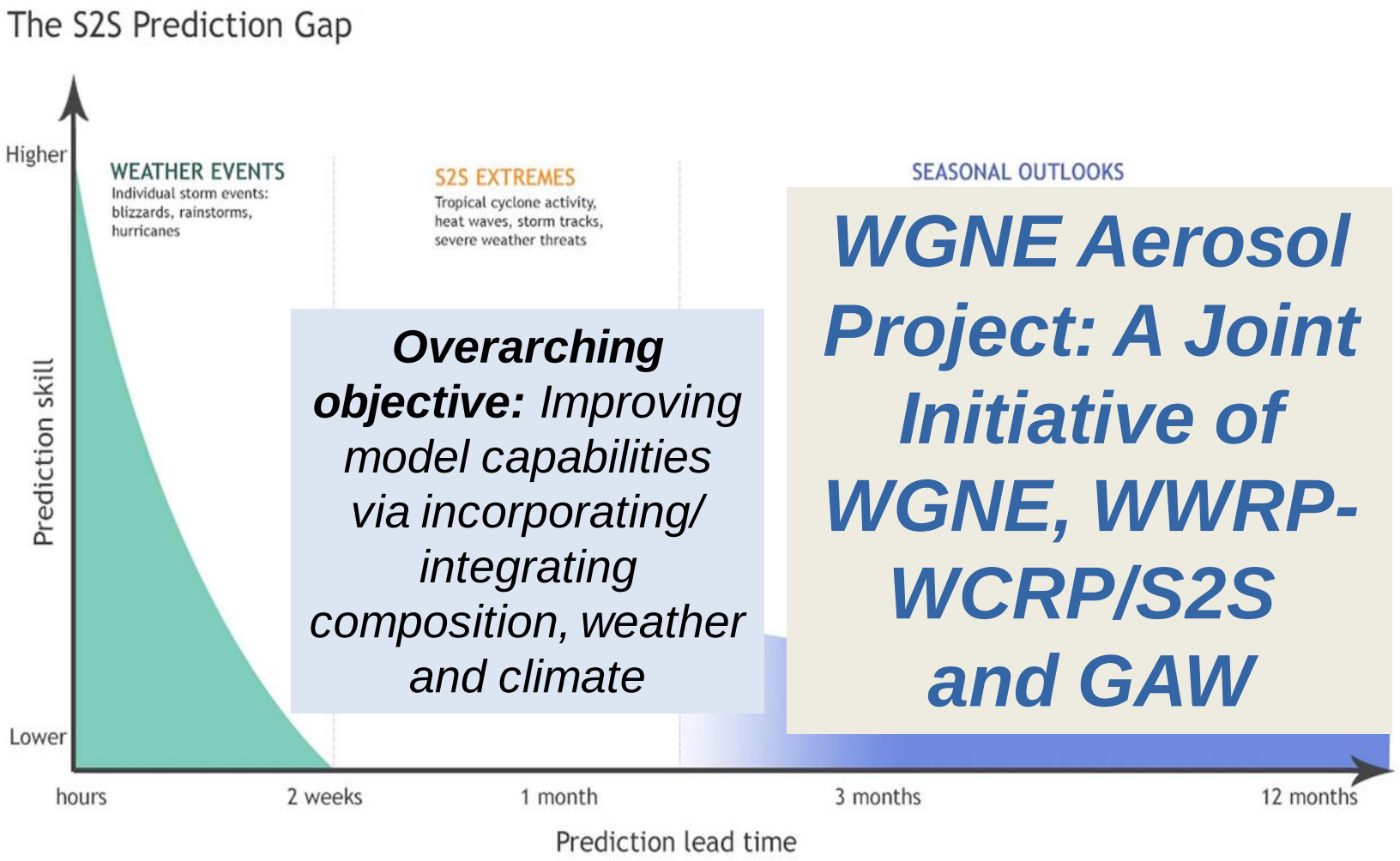

Overarching objective: *Improving model capabilities via incorporating/ integrating composition, weather and climate*

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

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

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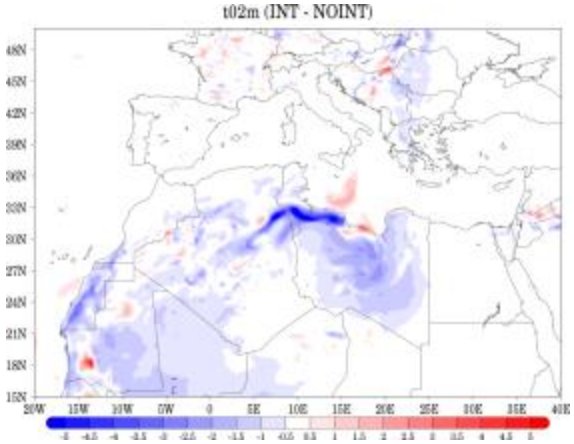
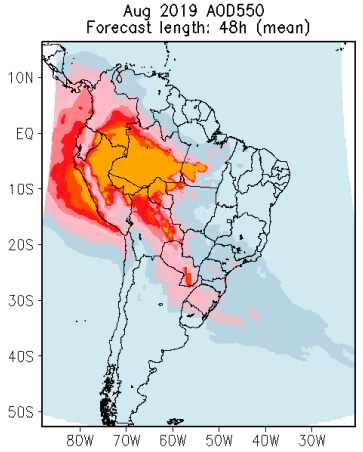
Experiments - Direct effect

Short-range Regional domains
Period of simulations: 2017-2019 (2016 optional)
Forecast lenght: 72h from 00:00 UTC
Time resolution: 3h
Configuration: according with modelling groups capability
Aerosols: Focus on different aerosol species according with region of interest Climatological vs interactive

WRF/ARW/IAASARS 36h-forecast differences - 27/10/2010 at 12:00 UTC



S. America – mean AOD fct 08/2019 at 00:00 UTC

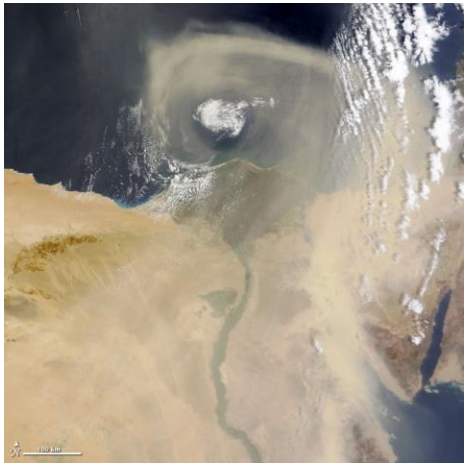


S2S Re-forecast Experiments

Aerosol events to be analyzed

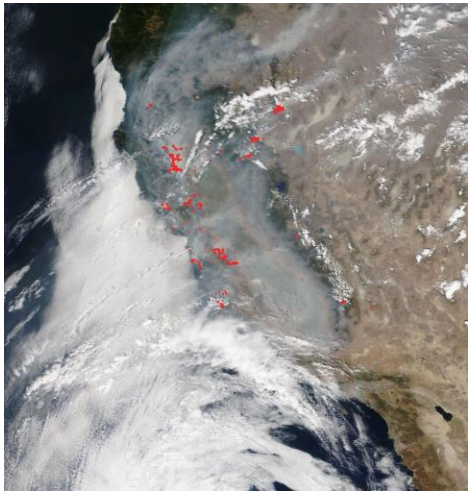
Direct effect (indirect effect optional)

Dust



Dust Storm over Egypt and Libya, May 27, 2010, NASA

Biomass Burning Smoke



NASA's Terra satellite captured the smoke-engulfed state on Aug. 24, 2020

Pollution in Asia is included as an additional and optional experiment

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

Participants	Status	Delivery	Contact
ECMWF	Completed	In progress	Angela Benedetti Frederic Vitart
NOAA	In progress	In progress	Georg Grell, Shan Sun
NASA	Completed	Completed	Zhao Li Andrea Molod
ECC	In progress	In progress	Knut von Salzen Paul Makar
CMA	In progress	In progress	Junchen Yao Tongwen Wu
JMA			Yuhei Takaya

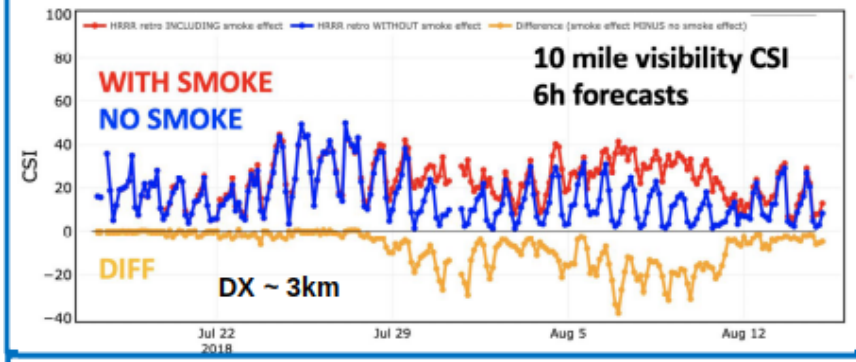
Regional

Participants	Status	Delivery	Contact
ECMWF	Completed (S. America)	Completed	Johannes Flemming
INPE	*Completed (S. America)	Completed	Ariane Frassoni
NOA/IAASARS	Completed (Mediterranean)	Completed	Christos Spyrou
JMA			Taichu Y. Tanaka
Leibniz TROPOS			Roland Schrödner
CMA			Xiao-Ye Zhang / Wang Hong

* Planning a new run

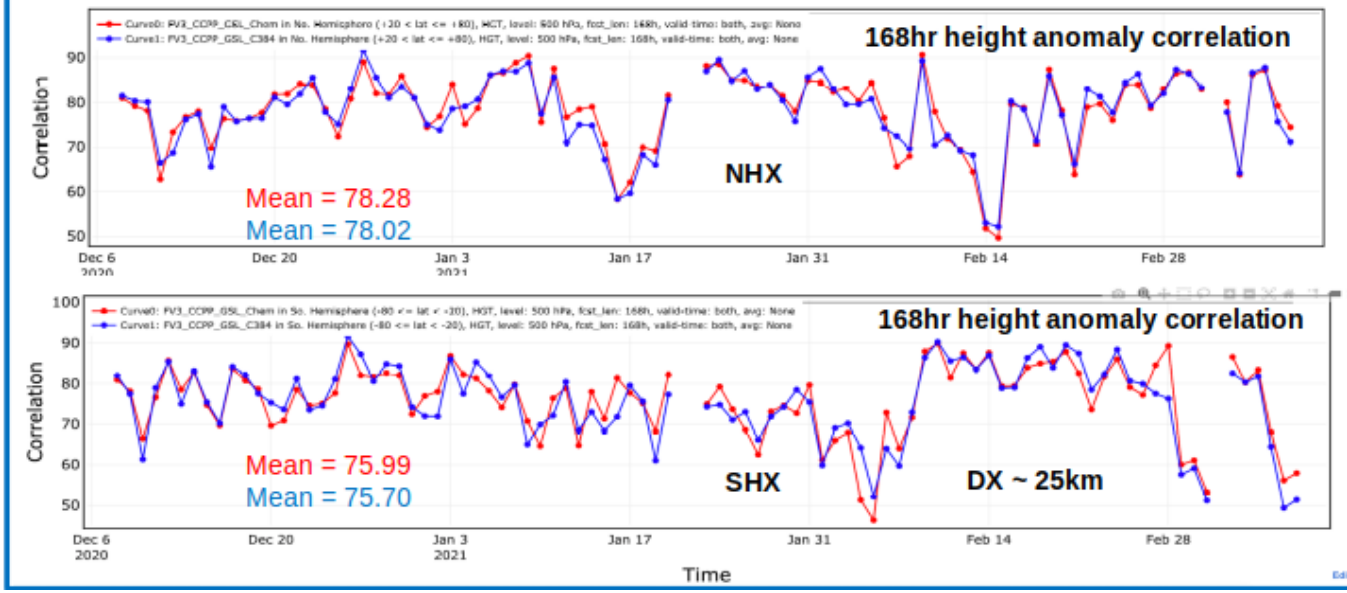
S2S Deadline to deliver model data – to be extended to early-December 2021

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

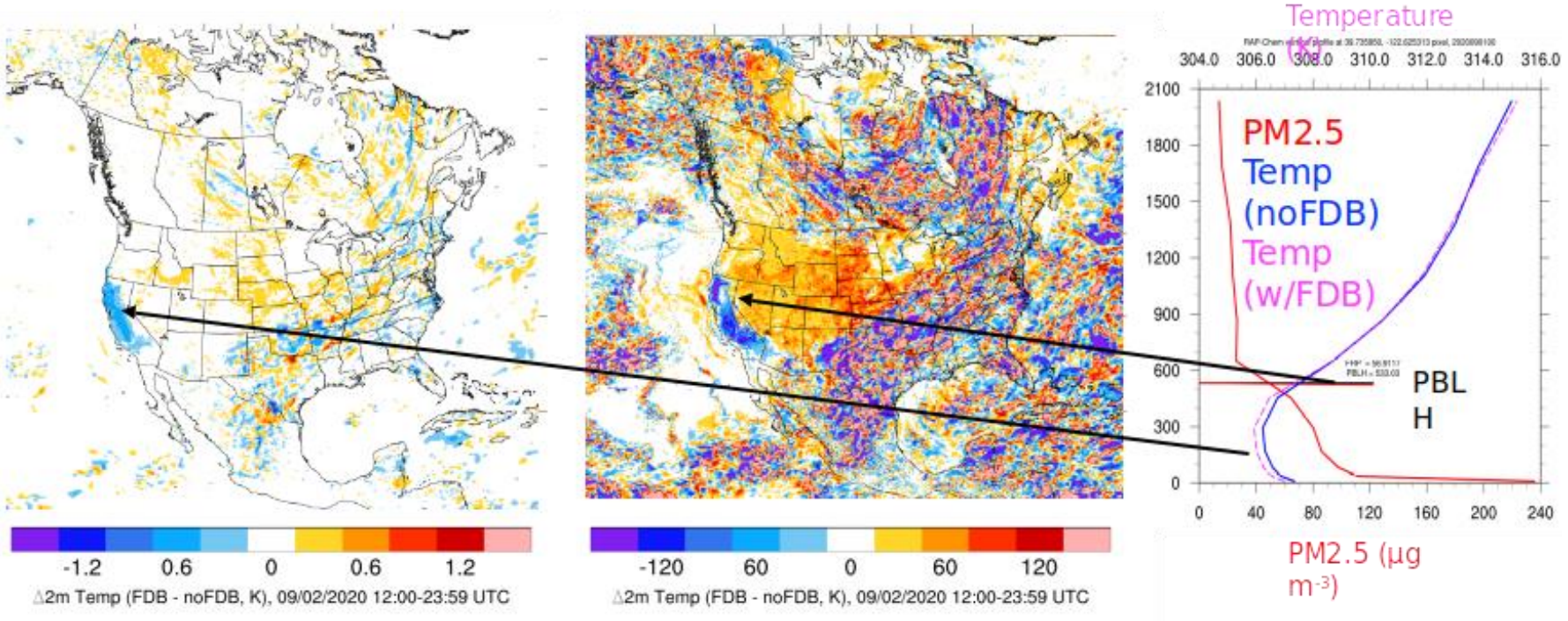
With feedback

No feedback

Courtesy: Grell et al., 2021

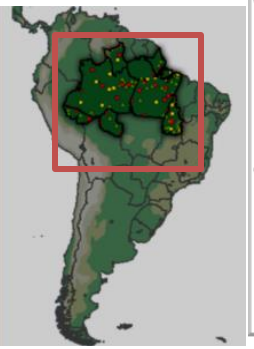
WGNE Aerosol project: covers the **1-30 September 2020** *wildfire* period: evaluating the impact of aerosols on weather (and AQ) prediction with **RAP-Chem**

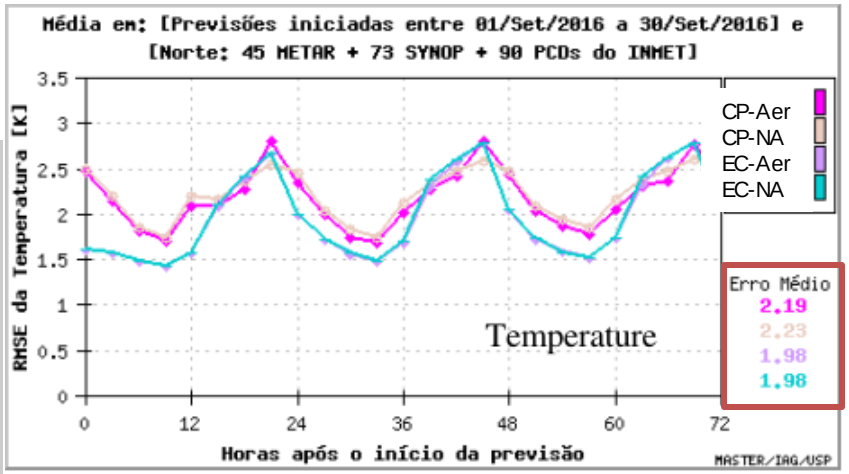
Mean daytime difference in 2m temperature (K) and PBL height (m)

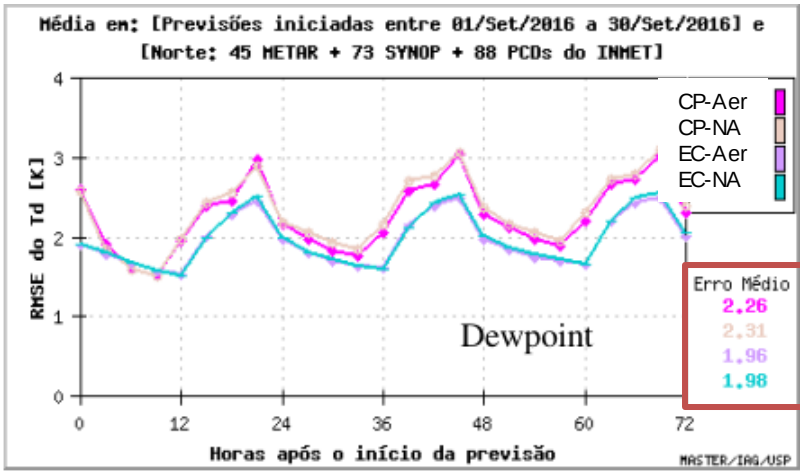


Modest changes in temperature and atmospheric structure when the direct effect on radiation is included

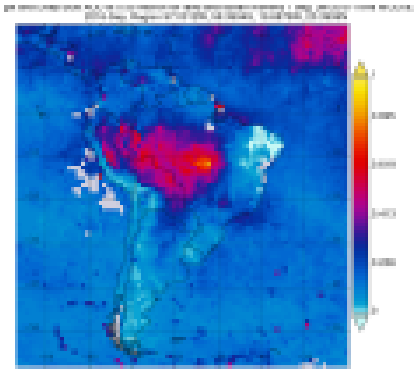
RMSE – Northern Brazil 09/2016

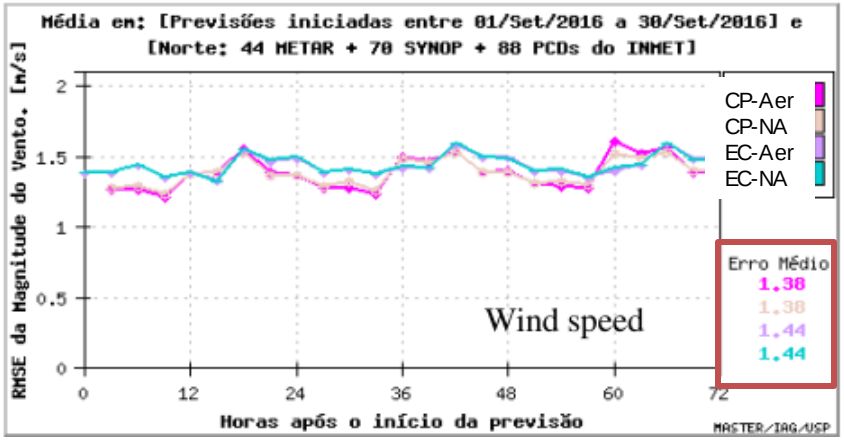






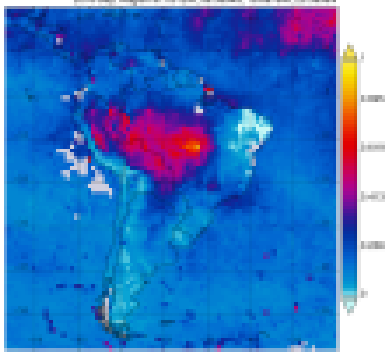
09/2016 Mean AOD - NASA

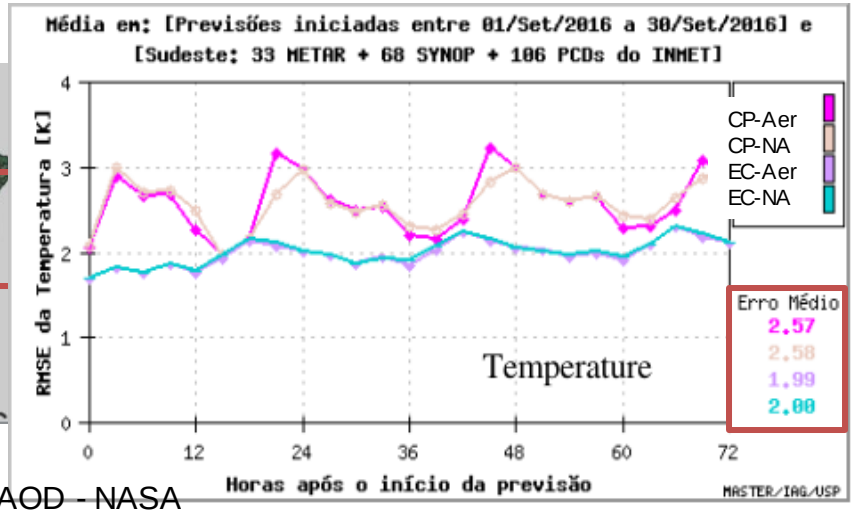


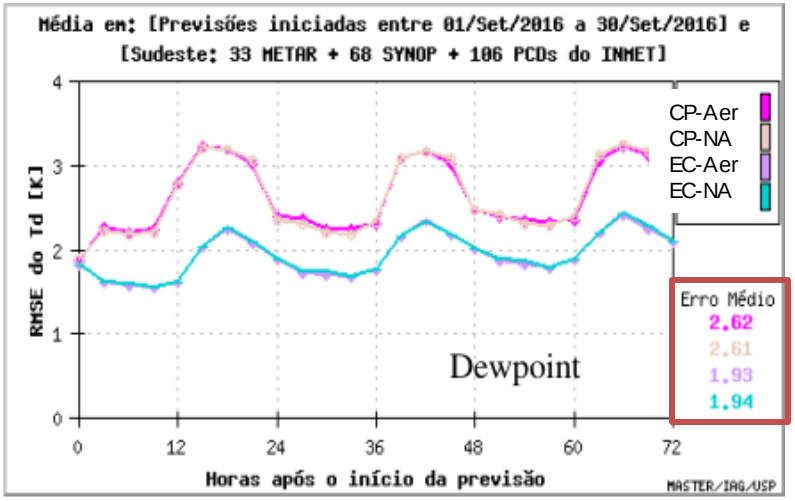


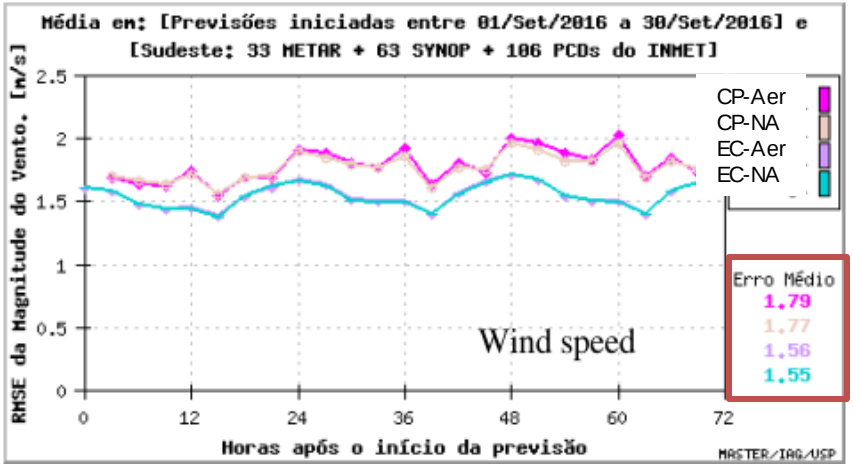
RMSE - Southeastern Brazil 09/2016

09/2016 Mean AOD - NASA





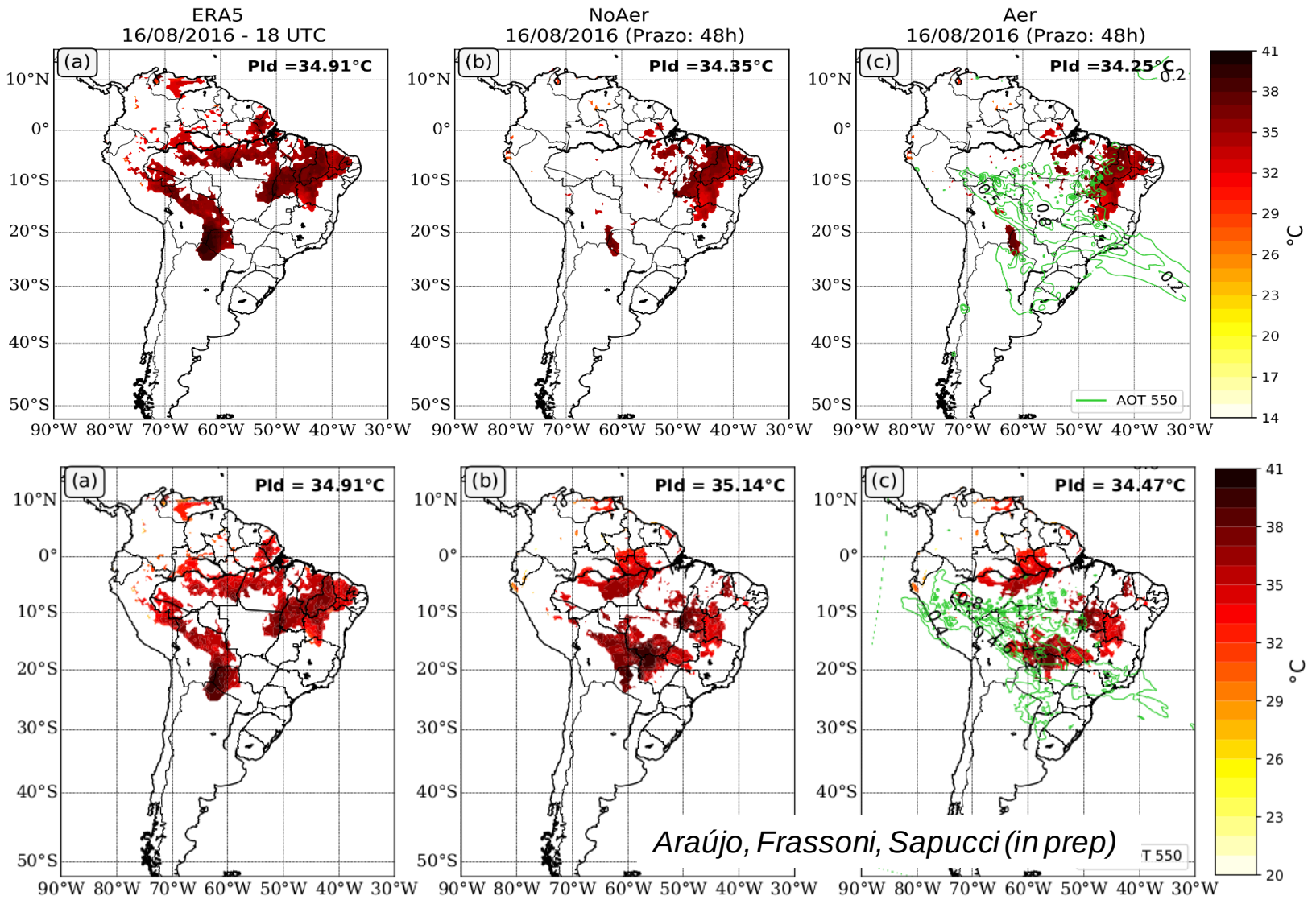




Extreme events – Heat waves

ECMWF

INPE/ CPTEC



Next steps

- Apply stat. significance tests for the results
- Progress with verification against ERA5
- Perform AQ quantitative verification
- Perform S2S verification after model data delivery – prob. Dec-Jan

Acknowledgements

GAW

WCRP
World Climate Research Programme

WWRP
WORLD WEATHER RESEARCH PROGRAMME

Subseasonal-to-Seasonal
S2S
Prediction Project

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

Thanks for your attention!