The 2nd Phase of the WGNE Aerosol project: Evaluating the impact of aerosols on Numerical Weather and Subseasonal Prediction

A joint collaboration between WGNE, S2S and GAW

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With inputs from: Saulo Freitas et al. (1st Phase project lead)

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WMO GAW Modelling Applications Science Advisory Group
(APP SAG) and the Monitoring, Analysis and Prediction of Air Quality (MAP-AQ)
GAW key project science team meeting
Geneva, Switzerland
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Evaluating the Impact of Aerosols on NWP and Subseasonal Prediction

WGNE - *Working Group on Numerical Experimentation*

fostering the **development of atmospheric circulation models** for use in weather prediction and climate studies on **all time scales**, and **diagnosing and resolving shortcomings**.

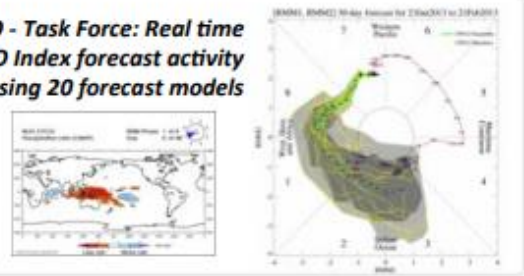
Objectives are achieved through

- Identification of **systematic errors** common to many models.
- Sharing **diagnostic tools and techniques** to get to the root of the error.
- Sharing knowledge around **sensitivity of errors to model formulation** (parametrizations, dynamical core, etc.).
- Work with other groups (e.g. GASS & GLASS) to **develop solutions**.

Cases of strong or persistent events of aerosol pollution studied by the WGNE Aerosols project

1) Dust over Egypt: 4/2012 2) Pollution in China: 1/2013 3) Smoke in Brazil: 9/2012

MJO - Task Force: Real time MJO Index forecast activity using 20 forecast models



Keith Williams, 2017, Pan-WCRP Modelling Groups Meeting

The First Phase of the WGNE-Aerosol Project (WGNE-AerI)

1) Identify the importance of aerosols for the predictability of the atmospere

2) Identify the importance of atmospheric model quality for air quality forecasting

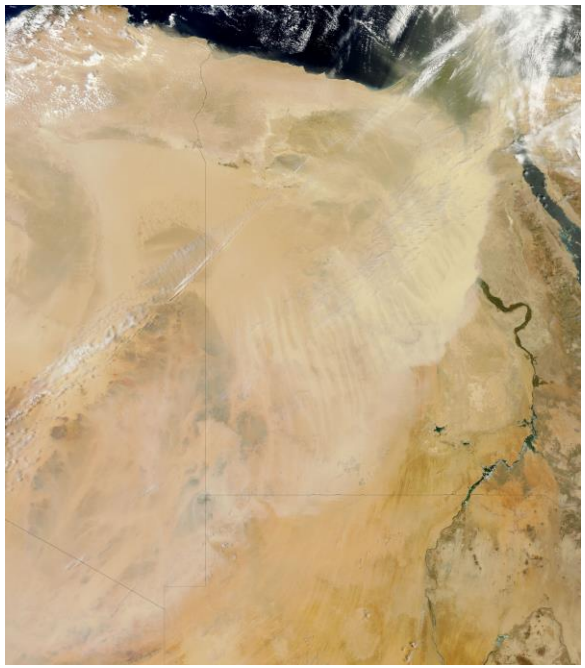
3) Analyse capabilities of NWP models to simulate aerosol impacts on weather prediction

WGNE Aer Phase 1 - Participating Models

Institution Model	Domain Resolution	Aerosol Species	A & BB Emissions	Aerosol Physics	Cloud Physics	Aerosol Assim.
CPTEC BRAMS	Regional 20 km	BC, Sea-Salt, OC, SO4	EDGAR 4. 3BEM	bulk	2-mom	no
JMA MASINGAR	Global TL319L40	Dust, Sea-Salt, BC, OC, SO4	MACCity GFAS 1.0	2-mom	2-mom	no
ECMWF Global	Global T511L60			Bulk	Bulk	yes
Météo-France ALADIN + ORILAM	Regional 7.5 km	Dust	DEAD model	3-mom log-no normal	Bulk	no
ESRL/NOAA WRF-Chem	Regional cloud res.	(many)	EDGAR 4. 3BEM	Bulk and Modal	2-mom	no
NASA/GSFC GEOS-5+GOCART	Global 25 km	Dust, Sea-Salt, BC, OC, SO4	EDGAR 4.1 QFED 2.4	Bulk	Bulk or 2-mom	yes
NCEP NGAC+GOCART	Global T126	Dust, Sea-Salt, BC, OC, SO4	Climatological Aerosols	Bulk	Bulk	no
Barcelona SC	regional	dust	BSC-dust model	8 dust size bins	Same as in WRF	no

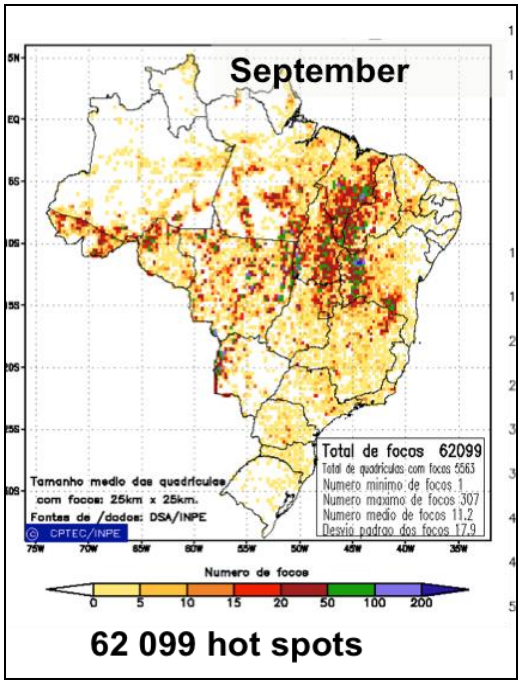
Courtesy: Saulo Freitas

Case Studies



Dust over Egypt: 4/2012

Pollution in China: 1/2013



Smoke in Brazil: 9/2012

Courtesy: Saulo Freitas

Main results

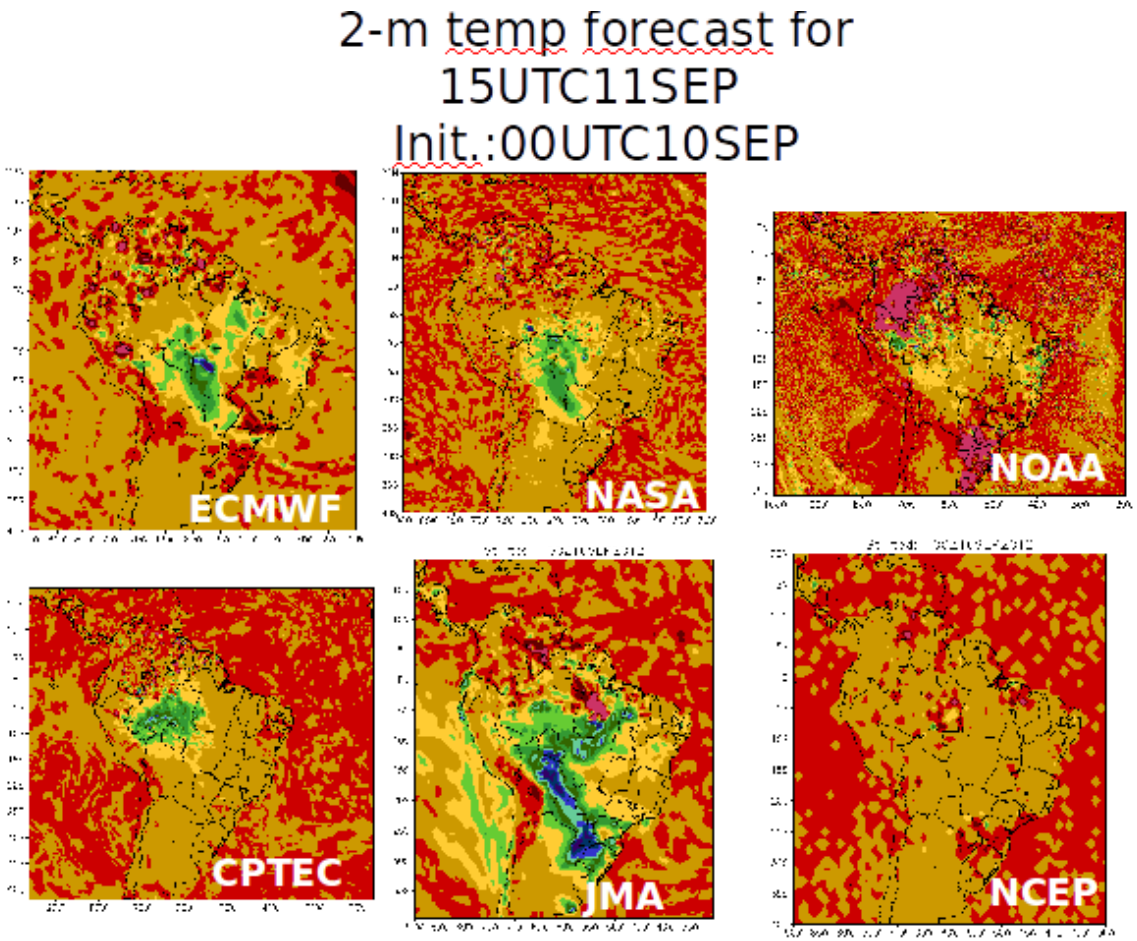
Significant discrepancies between models

Decrease in Radiative shortwave flux at surface and air temperature at 2m

Direct effect is important: improvements on NWP skill considering interactive aerosols

Misrepresentation of intense cases using climatological aerosols

Lack of statistical significance



Courtesy: Saulo Freitas

- Few operational meteorological centres are able to run a fully integrated weather/chemistry NWP system with interactive aerosols
- Less centres are able to run fully coupled modelling systems for longer timescales, like S2S
- All the operational S2S models contributing to the S2S WWRP–WCRP joint research project database use climatological aerosols

Subseasonal-to-Seasonal S2S Prediction Project

S2S WWRP–WCRP project recognizes the importance of aerosols on S2S timescales -> not explored in WGNE-AerI

The incorporation of interactive aerosols on S2S models:

- *Opportunity to improve the skill of models*
- *Contribute to support policy makers and end-users providing skillful air quality forecasts*

Importance of aerosols for S2S predictability

May-June 2003-2015

11 ensemble members

4 experiments:
→ Two different climatologies
→ Prognostic aerosols initialized using the time-varying CAMSira
→ Prognostic aerosols initialized using a fixed climatology (based on a CAMS experiments without data assimilation) –PROG2

Only direct effect was considered

Benedetti and Vitart (2018, MWR)

The Second Phase of the WGNE-Aerosol Project (WGNE-AerII)

Identify and quantify the importance of aerosols for the predictability of the atmosphere at **short-range and subseasonal** time scales

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

Identify and quantify the skill of air quality forecasting, especially on subseasonal time scale for impact purposes

The Second Phase of the WGNE-Aerosol Project (WGNE-AerII)

Systematic NWP experiment

Confirm results from WGNE-AerI considering a big sample size in order to obtain statistical significance for differences

S2S experiments

Subseasonal re-forecasting experiments based on ensemble approach on a global scale in order to address the importance of interactive aerosols on subseasonal predictability

Protocol: limited area domain (focus on NWP)

Proposed years: 2016-2018
Forecast length: 72h from 00:00 UTC
Time resolution: 3h

Configuration: as in operation
Variables: see the list

Event	***Period***	***Domain***	***Center of domain***	***Effects to be analysed***
Dust in Egypt	Mar-Apr-May	from Eq. to 50°N, Eq. to 60°E	30°E, 25°N	Direct Indirect* Climatological
BB S. America	Aug-Sep-Oct	32°W to 76°W 33°S to 6°N	60°W, 10°S	Direct Indirect* Climatological
BB S. Africa	Aug-Sep-Oct	0°E to 60°E 40°S to 10°N	30°E, 15°S	Direct Indirect* Climatological
Pollution in Asia	TBD	TBD	TBD	Direct Indirect* Climatological

***Optional**

S2S Re-forecast Experiments

Experiment 1: Dust prediction and impact

- Starting dates 1st March/1st April/1st May 2003-2018
- Minimum 5-member ensemble
- At least 32-day long simulations
- Climatological aerosols vs prognostic aerosols (dust only)
- Initialized by own analysis/re-analysis
- Aerosol direct effect (indirect effect is optional)

S2S Re-forecast Experiments

Experiment 2: Biomass burning

- Starting dates 1st Aug/1st Sept/1st Oct 2003-2018
- Minimum 5-member ensemble
- At least 32-day long simulations
- Climatological emissions vs prescribed observed emissions
- Initialized by own analysis/re-analysis
- Aerosol direct effect (indirect effect is optional)

Protocol

Storage data: at CPTEC (10TB available), format: netcdf

Forecast verification (contribution from JWGFVR)

Regional	S2S	Air Quality/optical properties
RMSE	Bias of the ensemble mean	TBD
Bias	Correlation between ensemble mean and obs anomalies	
Contingency table scores	MSSS	
Scorecasrds	Standard deviation ratio	
	Fair CRPS	
	Scorecards	

Open tasks

- Define a reference database for model evaluation

- Define specific statistical scores for air quality and optical properties evaluation – ***JWGFVR contribution***

- Finish the draft protocol up to July: define a time-line of the experiments

- Include a regional domain for Asia (TBD)

- Share the protocol with partners to receive their feedback

- Launch the protocol with WGNE, S2S, APP and Aerosol SAGs Centers

Acknowledgements

GAW

WCRP
World Climate Research Programme

WWRP
WORLD WEATHER RESEARCH PROGRAMME

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

Subseasonal-to-Seasonal
S2S
Prediction Project

Thanks for your attention!