# Evaluating aerosols impacts on Numerical Weather Prediction: 3rd report

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With inputs from: Arlindo Silva, Angela Benedetti, Georg Grell, Oriol Jorba, Morad Mokhtari, Samuel Remy and

WGNE Members Participants



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# outline

- Introduction/Goals
- Brief description of the proposed case studies and protocols
- Centers participants and a brief description of their modeling systems
- Some highlighted results
- Webpage and tools under development for data analysis
- Discussion and planning.

# Goals of the Exercise

- This project aims to improve our understanding about the following questions:

- How important are aerosols for predicting the physical system (NWP, seasonal, climate) as distinct from predicting the aerosols themselves?

- How important is atmospheric model quality for air quality forecasting?

- What are the current capabilities of NWP models to simulate aerosol impacts on weather prediction?

# The general approach of the proposed work is:

- Select strong or persistent events of aerosol pollution worldwide that could be fairly represented in the current NWP model allowing the evaluation of aerosol impacts on weather prediction.
- Perform model runs both including and not the feedback from the aerosol interaction with radiation and clouds.
- Evaluate aerosol simulation
  - AOD or related parameter
  - Verification: AERONET, MODIS, MISR
- Evaluate aerosol impact on meteorology:
  - 2-meter temperature, dew point temperature, 10-meter wind
  - rainfall, surface energy budget, etc.

# Protocol: Variables

- Variables to compare:

| Variable name on 3 hours interval | Dimensio -nality | units | obs |
|---|---|---|---|
| 2m-Temperature | x,y | K | |
| 10m-wind direction and magnitude | x,y | Degree m/s | |
| Aerosol optical depth at 550 nm | x,y | - | |
| total aerosol mass column integrated | x,y | $Kg/m^2$ | |
| Precipitation (from convective parameterization) | x,y | mm | |
| Precipitation (from cloud microphysics at grid scale) | x,y | mm | |
| shortwave and longwave downwelling radiative flux at the surface. | x,y | $W/m^2$ | |
| temperature tendency associated to the total radiative flux divergence. | x,y,z | K/s (or dy) | |
| Temperature | x,y,z | K | |
| Relative Humidity | x,y,z | - | |
| Cloud drop number concentration | x,y,z | $cm^{-3}$ | |

- Output should be using a lat-lon rectangular grid. The preferred format is NETCDF.

# Protocol: Experiments

| Experiment | Direct Effect | Indirect Effect | No aerosol Interaction |
| --- | --- | --- | --- |
| 1 | X | | |
| 2 | | X | |
| 3 | X | X | |
| 4 | | | X |

# Participants

| Participants | Case 1 | Case 2 | Case 3 | Type of model | Status of the data | People Involved |
|---|---|---|---|---|---|---|
| CPTEC | | | X | R | aerosol direct effect only | Saulo Freitas, Mauricio Zarzur |
| JMA | X | X | X | G | ind, dir, ind+dir, no-aer | Taichu Tanaka, Chiasi Muroi |
| ECMWF | X | X | X | G | (aerosol direct effect only | Angela Benedetti, Samuel Remy, Jean-Noel Thepaut |
| Météo-France/Met. Serv. Algeria | X | | | R | aerosol direct effect only | Morad Mokhtari, Bouyssel Francois |
| ESRL/NOAA | | X | X | R | aerosol direct effect only | Georg Grell |
| NASA/Goddard | X | X | X | G | (direct effect only) | Arlindo da Silva |
| NCEP | X | | | G | (direct effect only) | Sarah Lu, Yu-Tai Hou, Shrinivas Moorthi, and Fanglin Yang |
| Barcelona Super. Ctr. | X | | | R | (aerosol direct effect only) | Oriol Jorba Casellas |

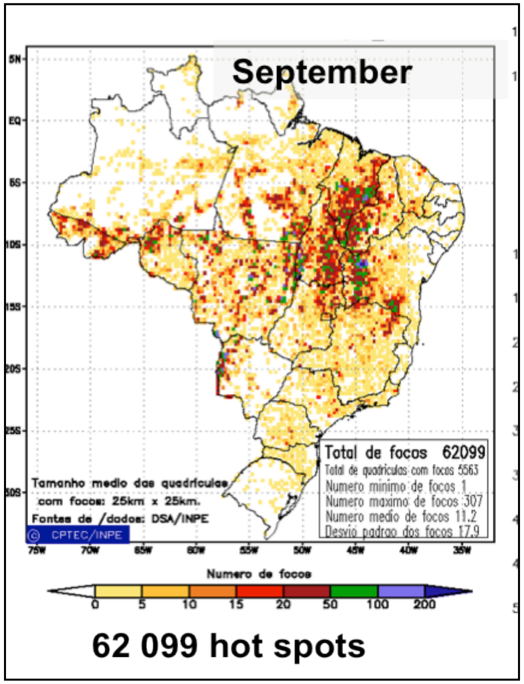
# Participating Models

| Institution Model | Domain Resolution | Aerosol Species | A & BB Emissions | Aerosol Physics | Cloud Physics | Aerosol Assimilation |
|---|---|---|---|---|---|---|
| CPTEC BRAMS LAM+CCAT | Regional 10 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 MG | 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 |

# Case Studies

1) Dust over Egypt: 4/2012

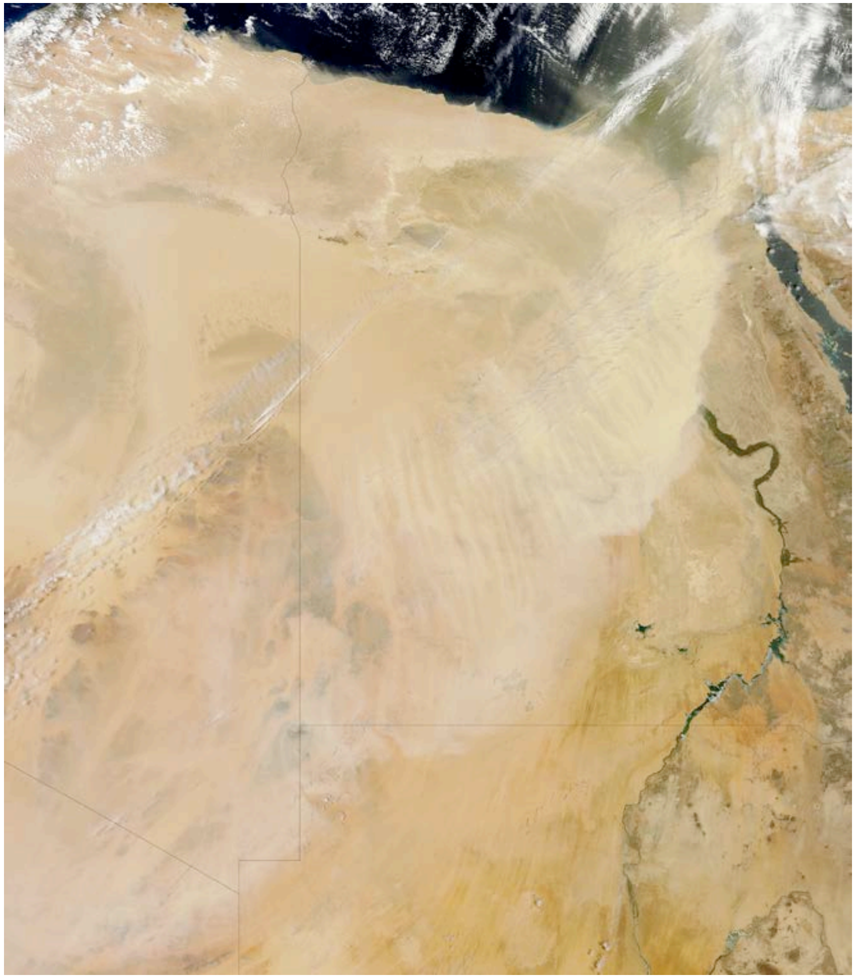
2) Pollution in China: 1/2013



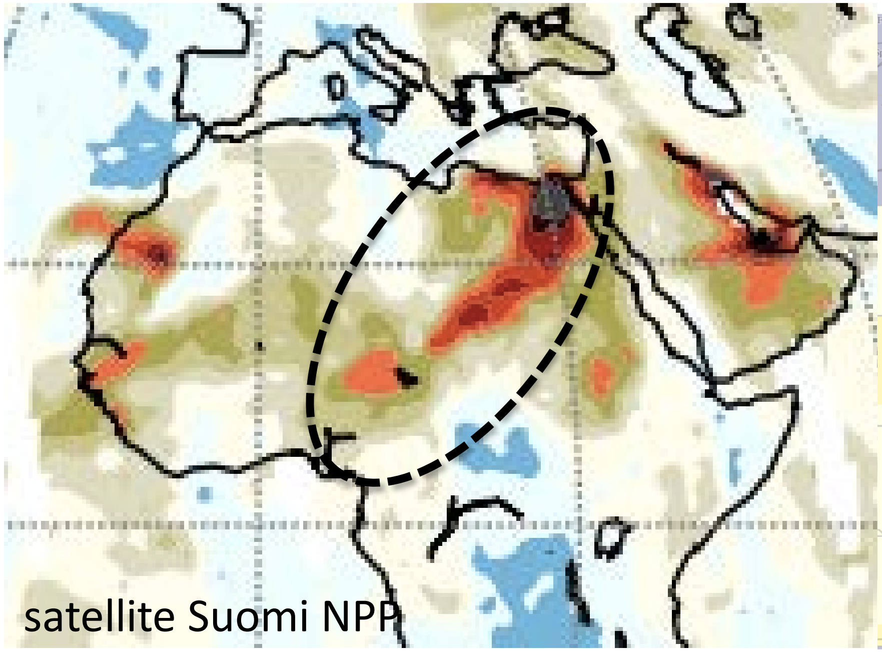

3) Smoke in Brazil: 9/2012

# Case 1: Dust Plume over Egypt

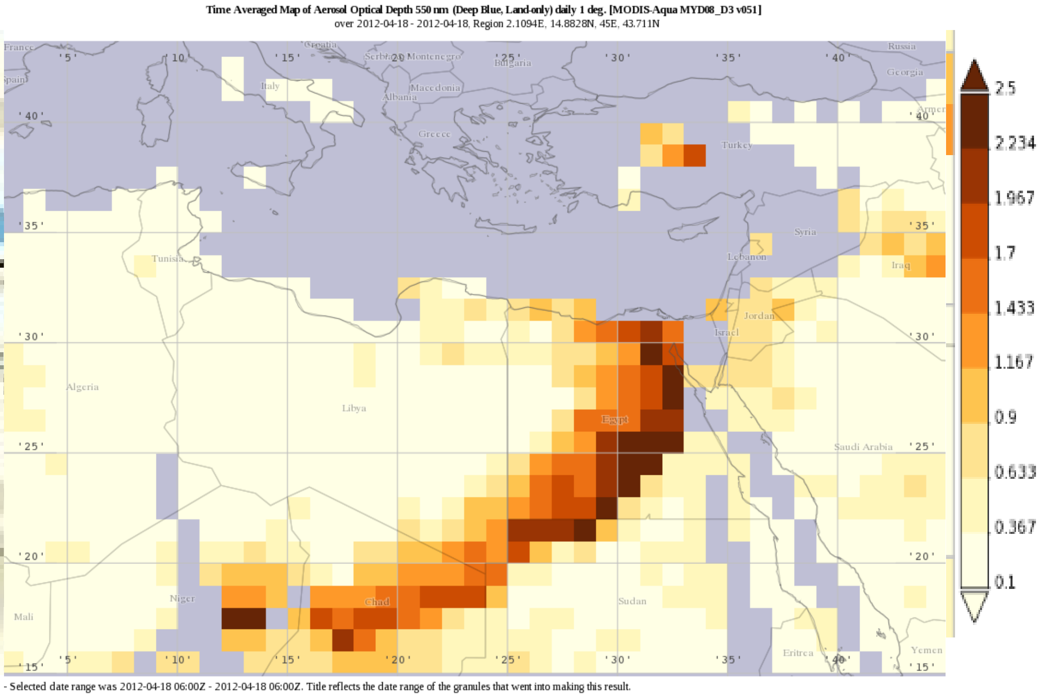
- 18 April 2012
- Forecasts
  - April 13-23 2012
  - From 0 or 12 UTC
  - 10 day forecasts
- Center of domain
  - 30E, 25N
- Model configuration
  - Same as for NWP
- Direct effects only



**OMPS UV Aerosol Index**
**18 April 2012**

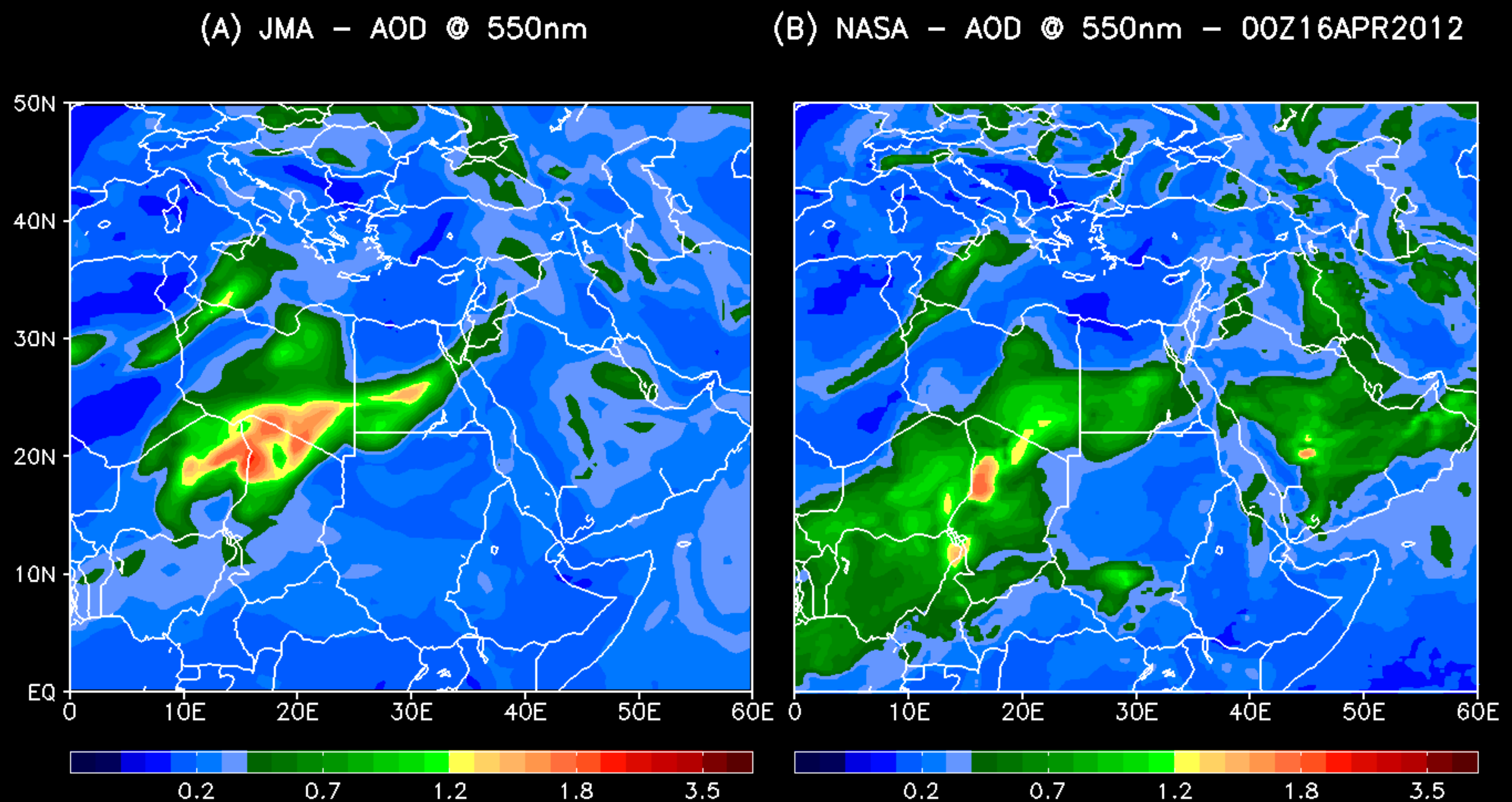



**MYD08_Aerosol_Optical_Depth_550_Land**
**18 April 2012**



# CASE 1 – DUST

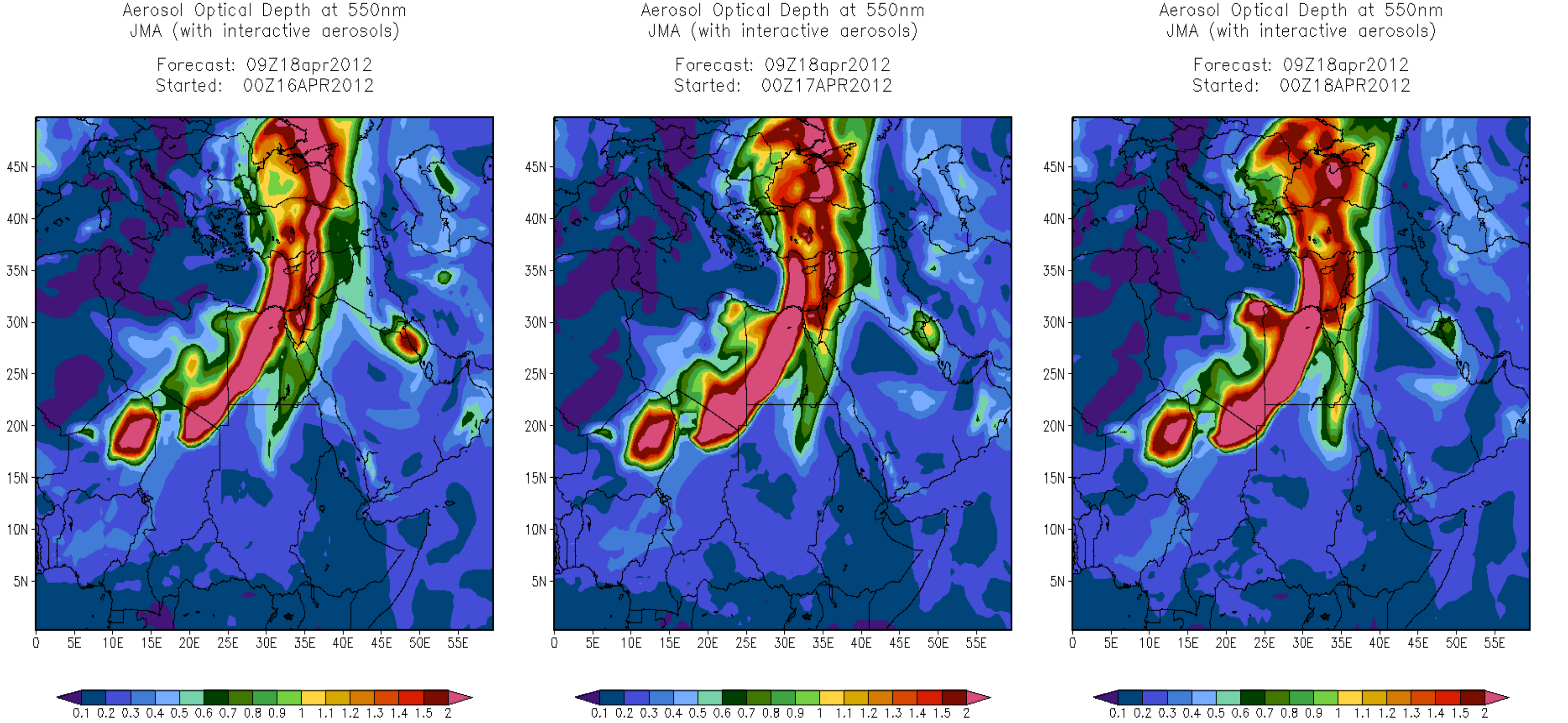
## JMA and NASA AOD (550 nm) FCT



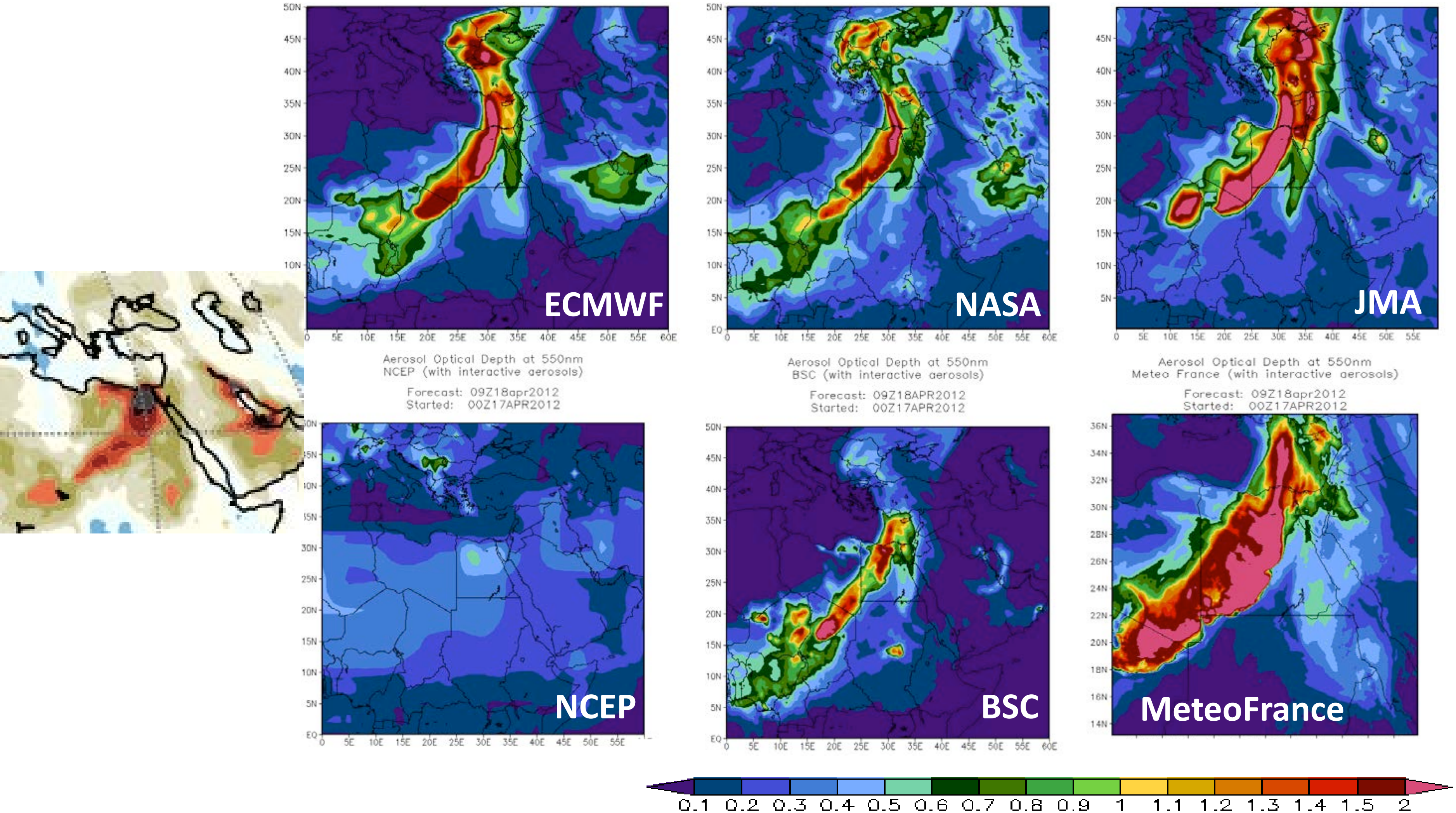
WGNE Exercise
Evaluating Aerosols Impacts on Numerical Weather Prediction

# AOD Forecast from JMA: 09UTC18Apr2012

Init.: 00UTC16 (57h) | Init.: 00UTC17 (33h) | Init.: 00UTC18 (09h)



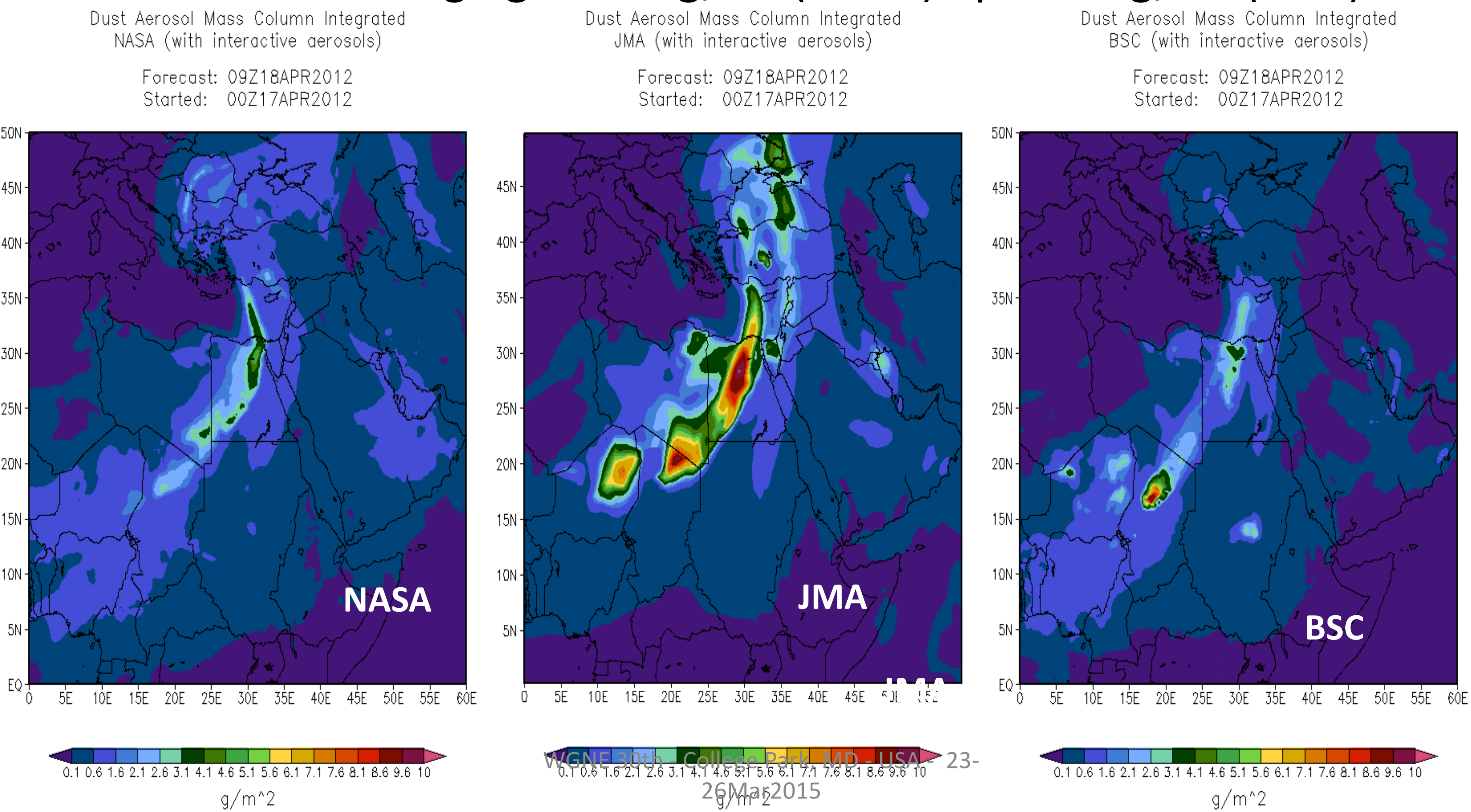
# AOD at 550nm: Forecast 09UTC18apr2012
# Init: 00UTC17apr2012




- NCEP : climatology does not capture the strong event (as expected).
- Another centers have similar pattern in terms of spatial distribution.
- AOD values : MF > JMA ~ ECMWF > NASA ~ BSC

# Column Integrated mass of dust

Large differences on dust mass:
max values ranging from 4g/m$^2$ (NASA) up to 20 g/m$^2$ (JMA).

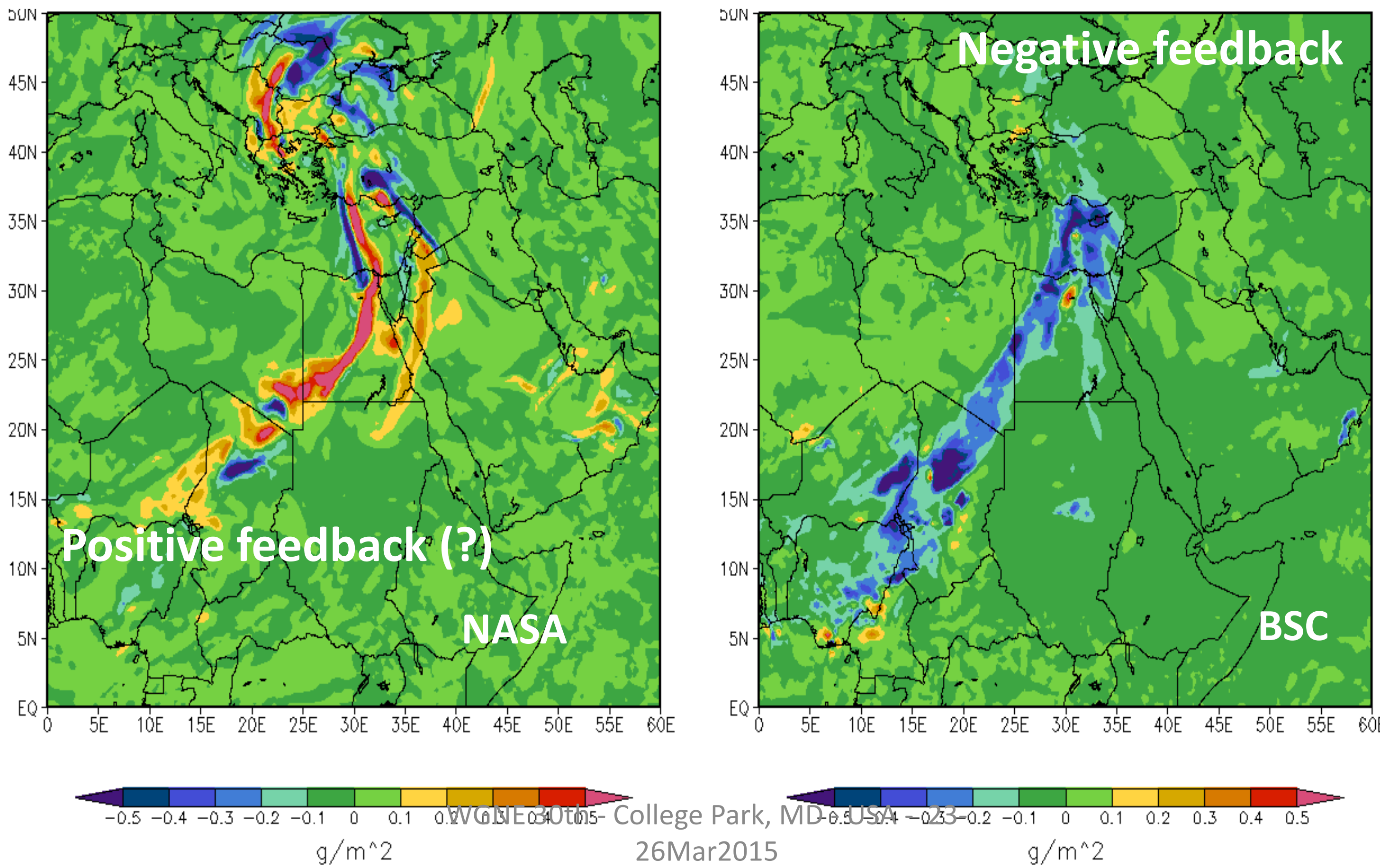


# How much interactive aerosol dust changes dust concentration itself?

## Mass of dust column integrated (AER-NOAER)

forecast 09UTC18APR2012

Init.:00UTC17APR2012

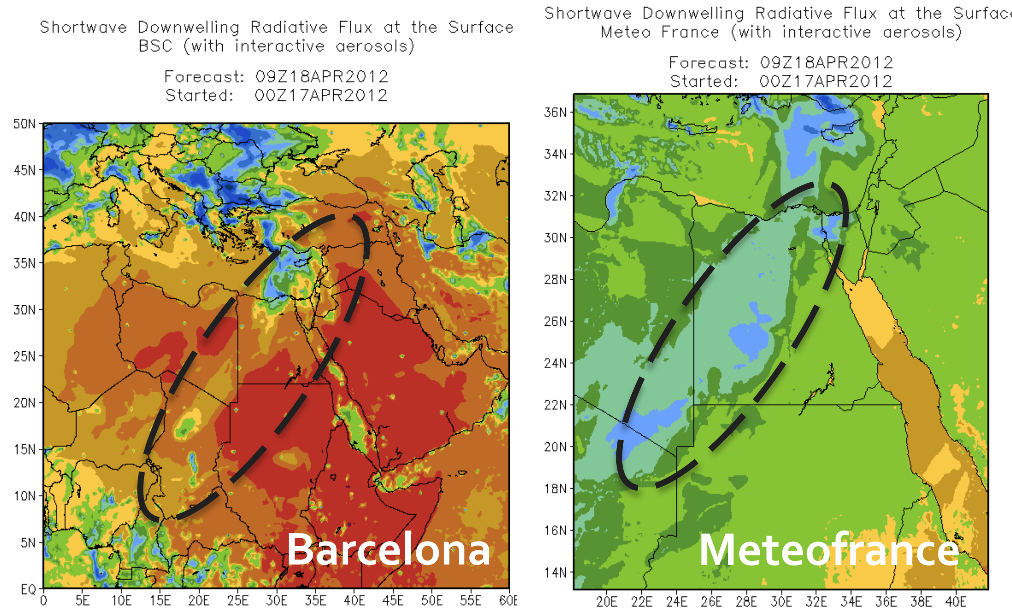


# Impacts on weather forecasting

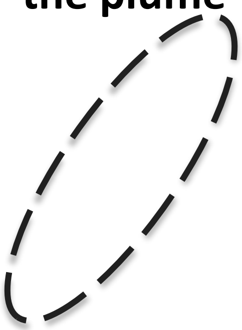
- Radiative short/longwave flux at surface
- Air temperature at 2m

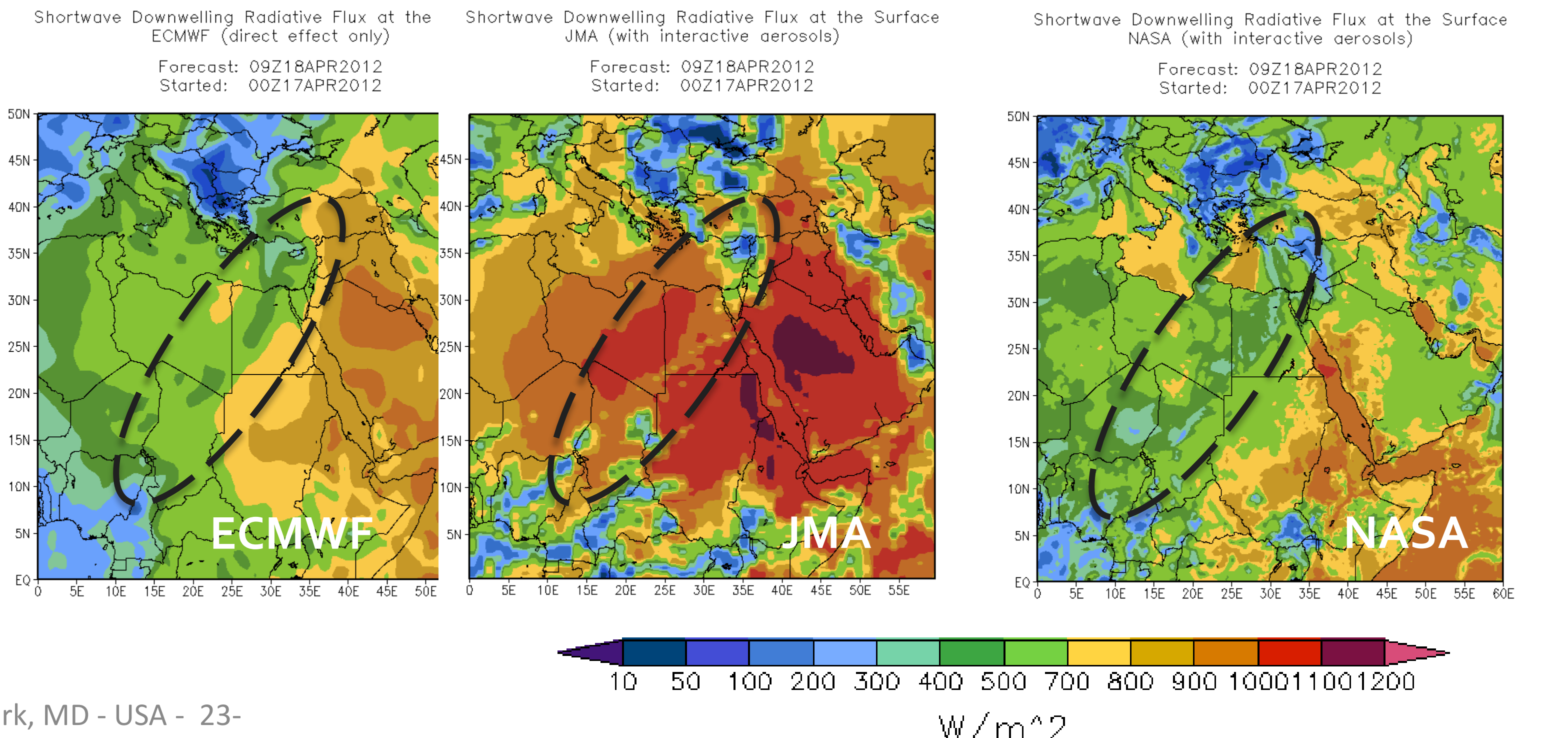
# SW Rad @ Sfc Intercomparison

- 9 UTC (morning)
- Large discrepancies among centers

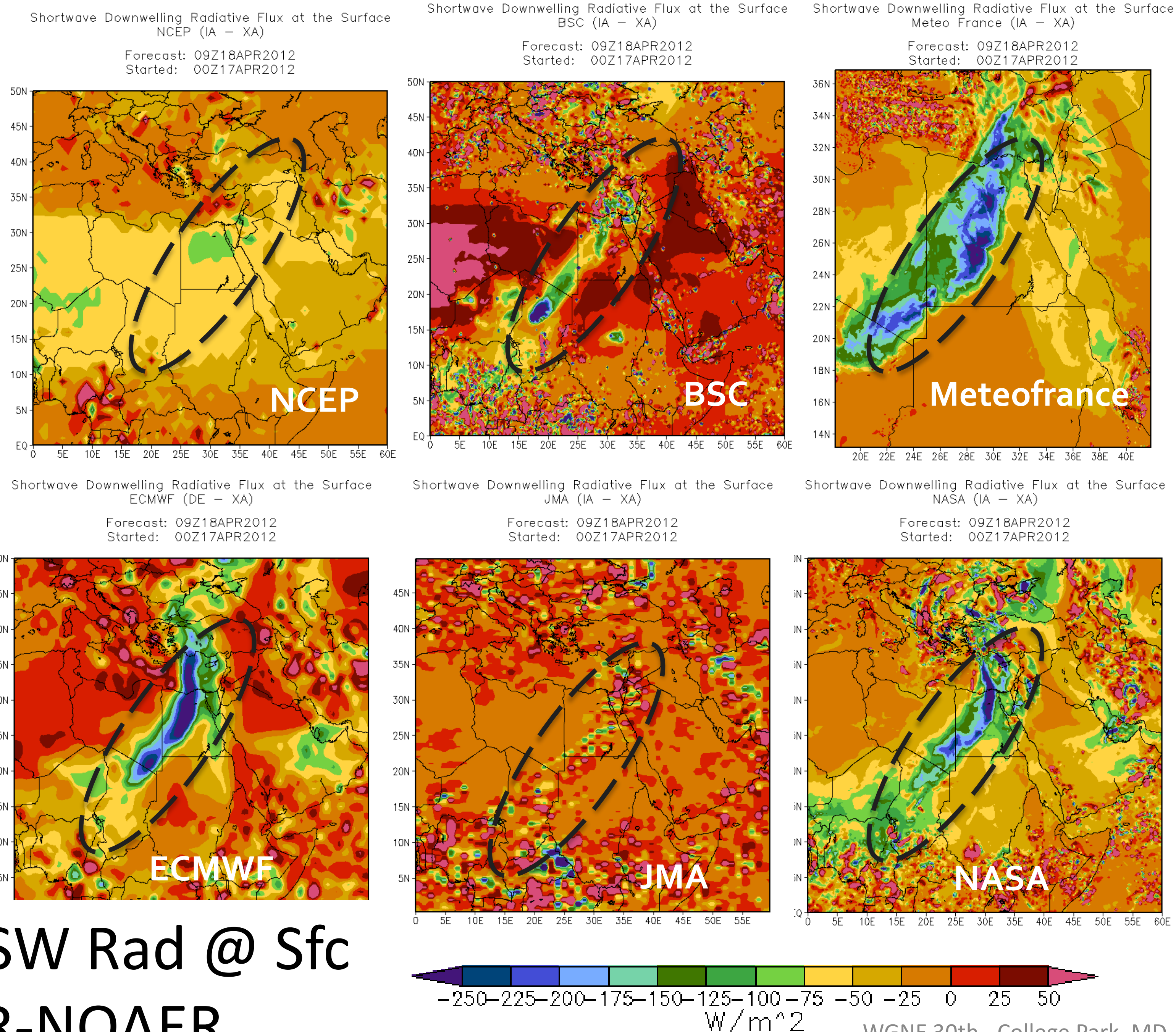



**Location of the plume**



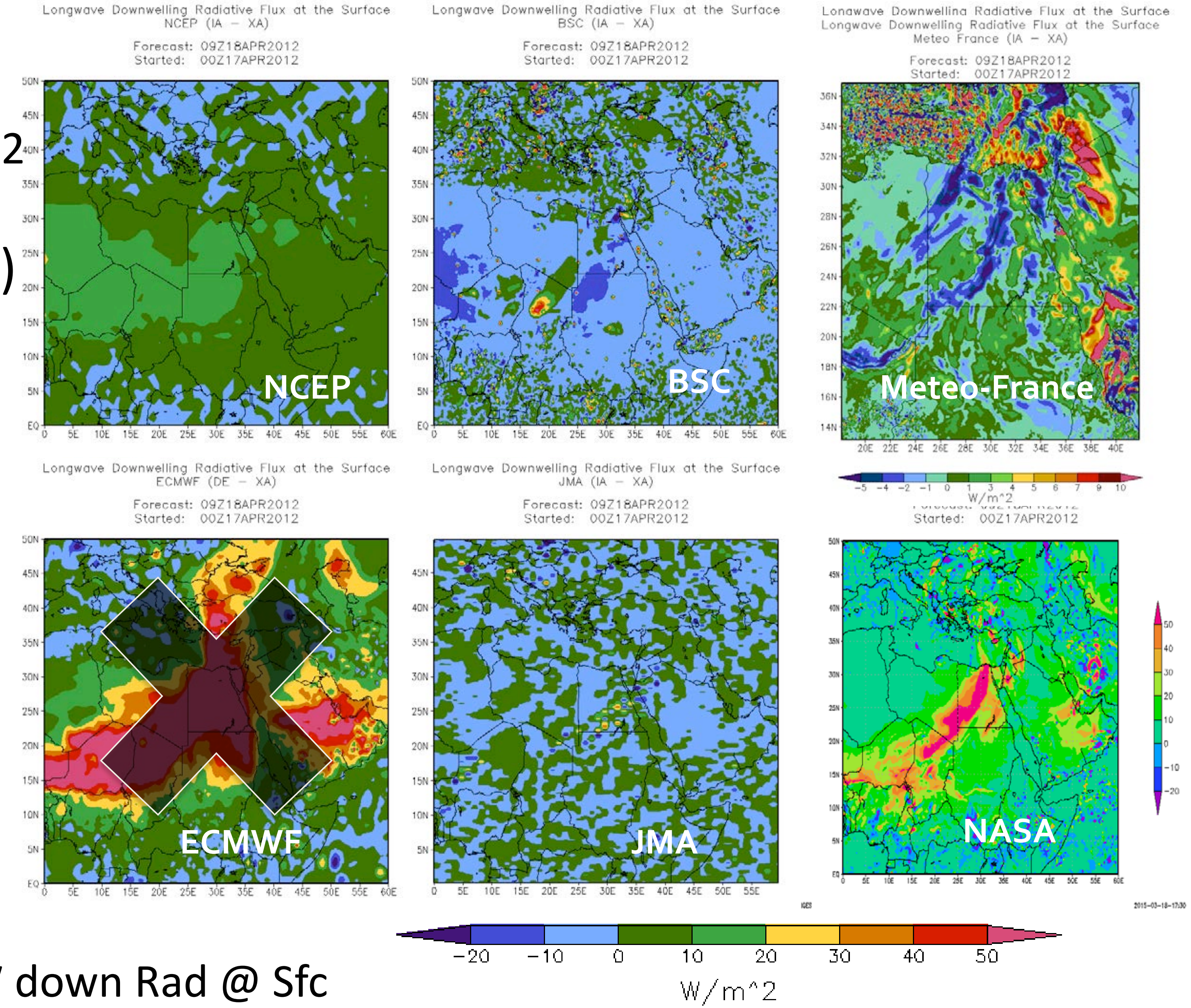


18APR2012
09 UTC
(morning)




DIFF of SW Rad @ Sfc
AER-NOAER

18APR2012
09 UTC
(morning)

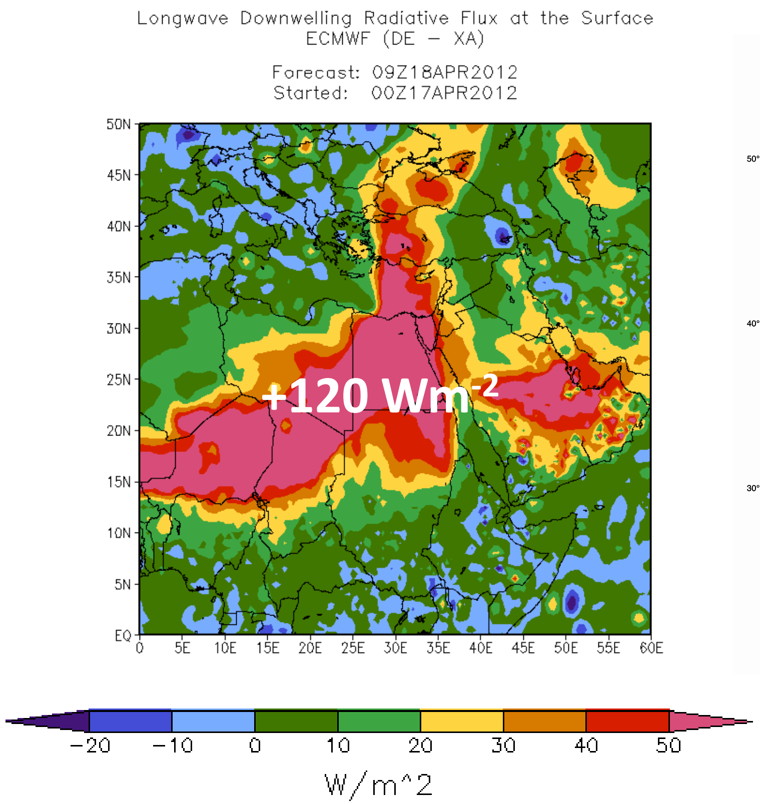



DIFF of LW down Rad @ Sfc
AER-NOAER

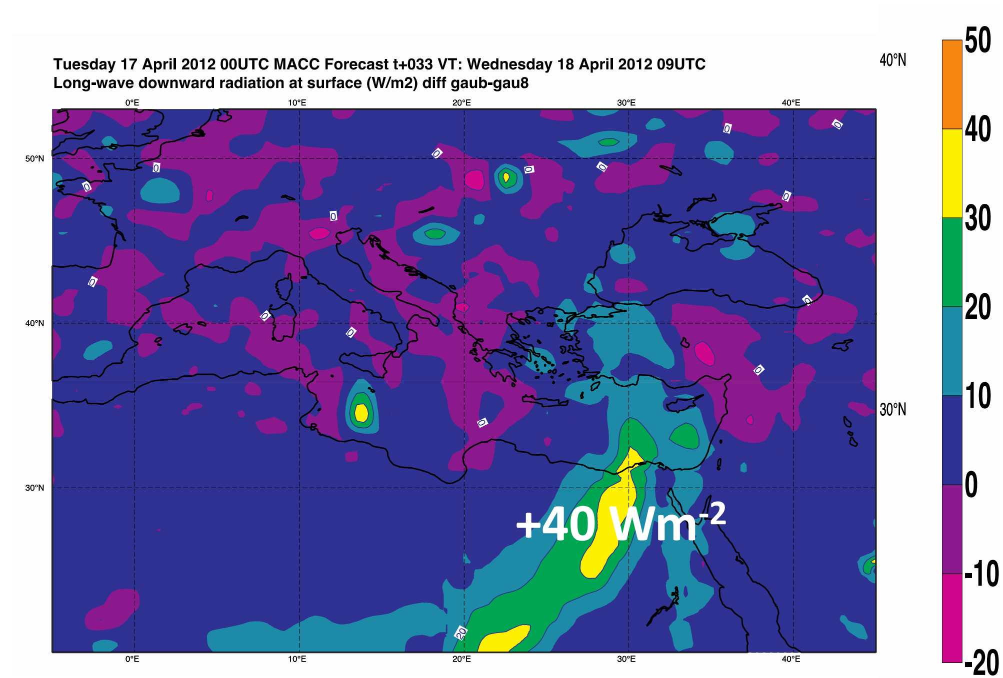
# DIFF of LW downward radiation at surface
# AER-NOAER

## 18APR2012 09 UTC (morning)

### Before

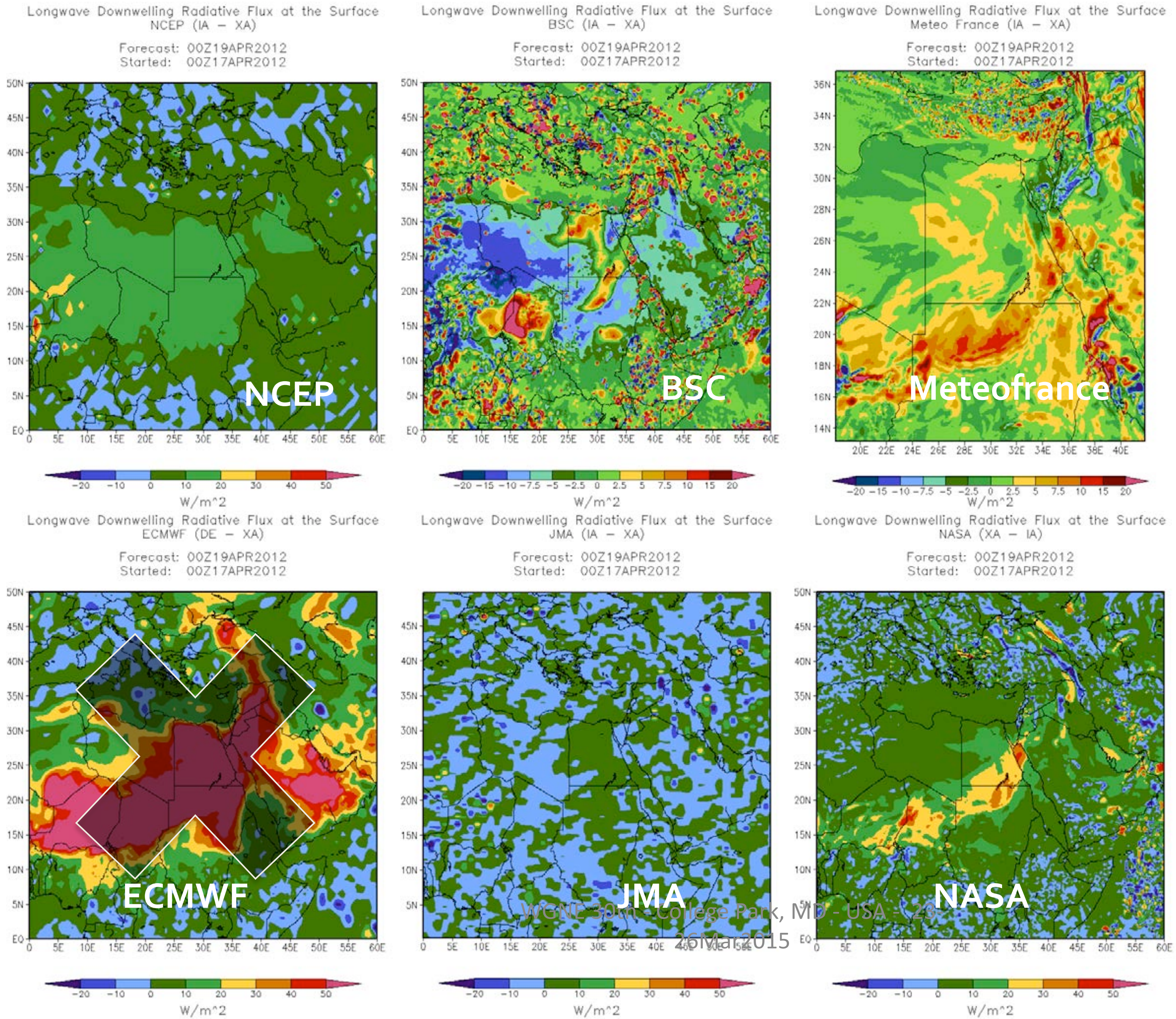



### After bug fix



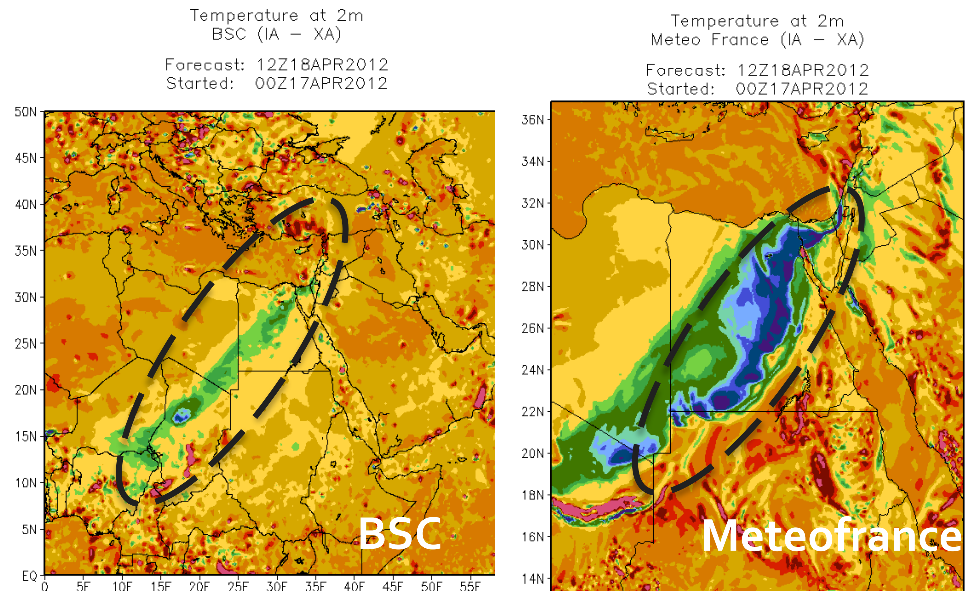
# DIFF of LW down radiation at surface: AER-NOAER

19APR2012
00 UTC
(nighttime)
48h
forecast

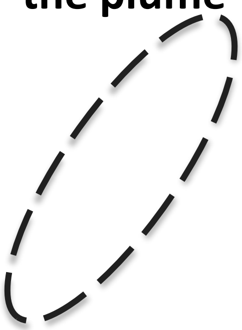


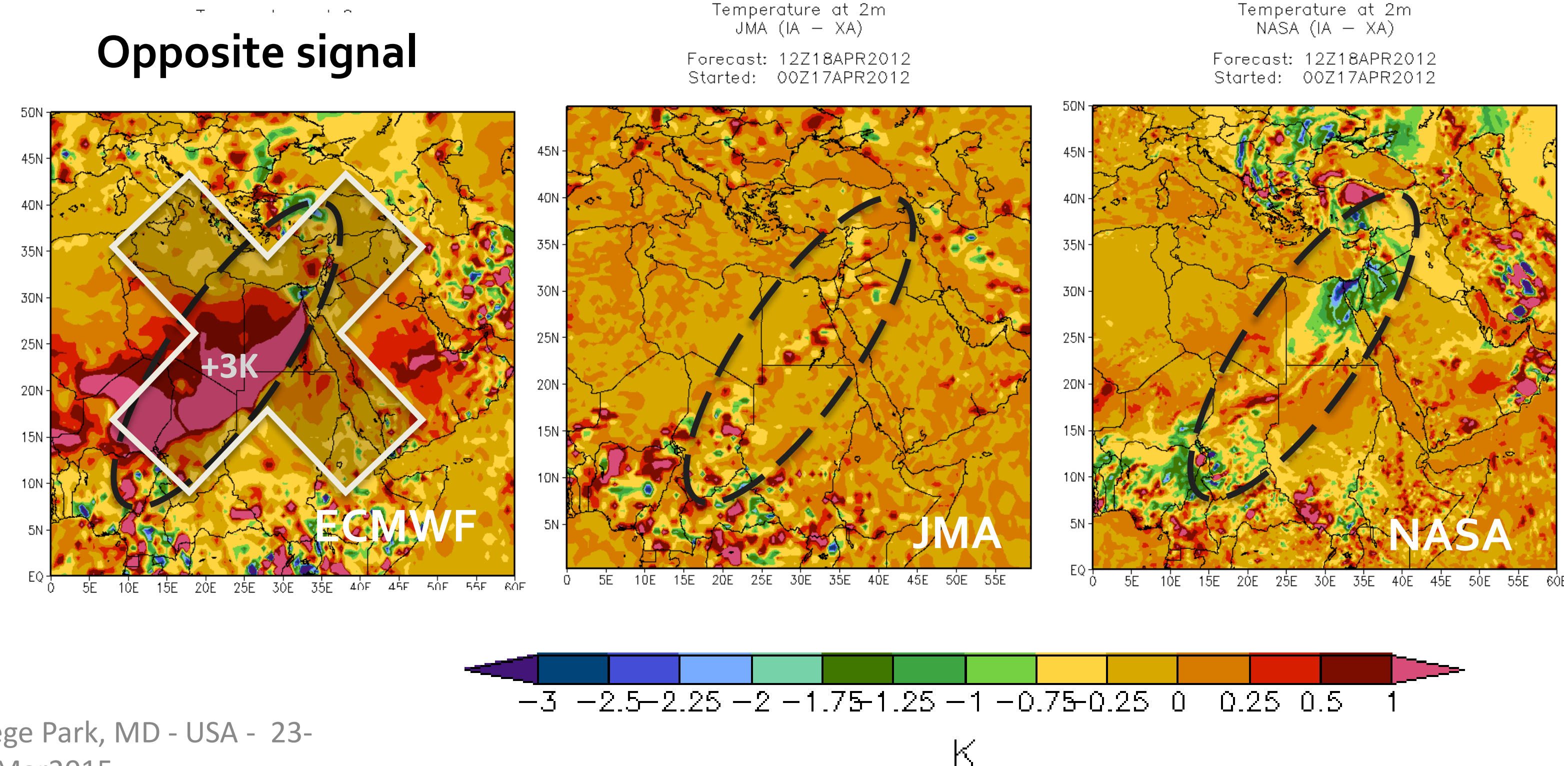
# DIFF of Temp @ 2-m AER-NOAER

- 12 UTC (morning)
- Large discrepancies among centers




**Location of the plume**

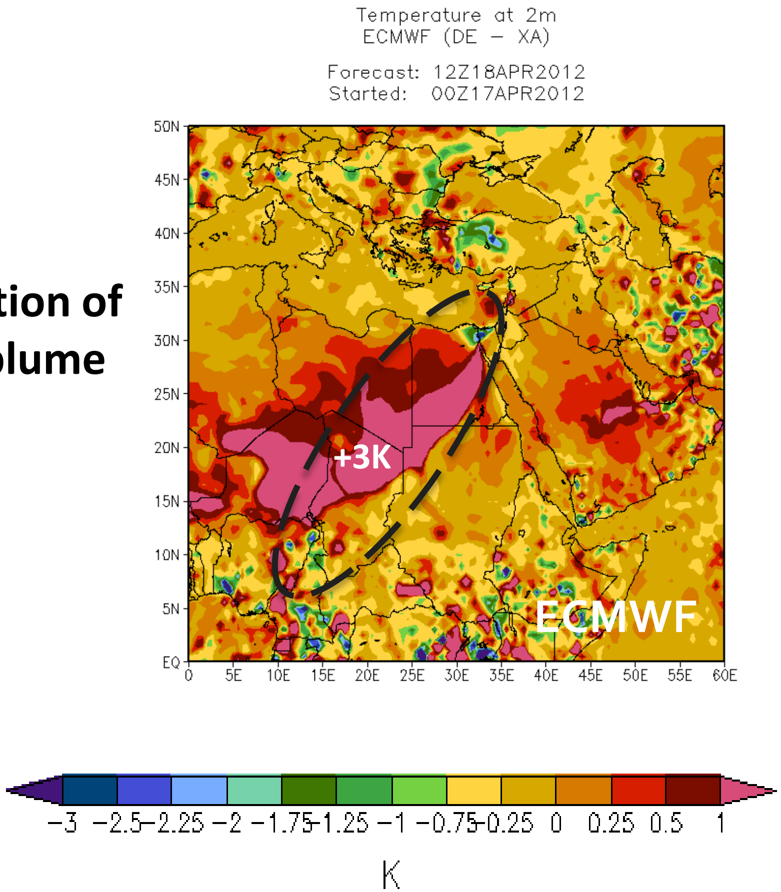




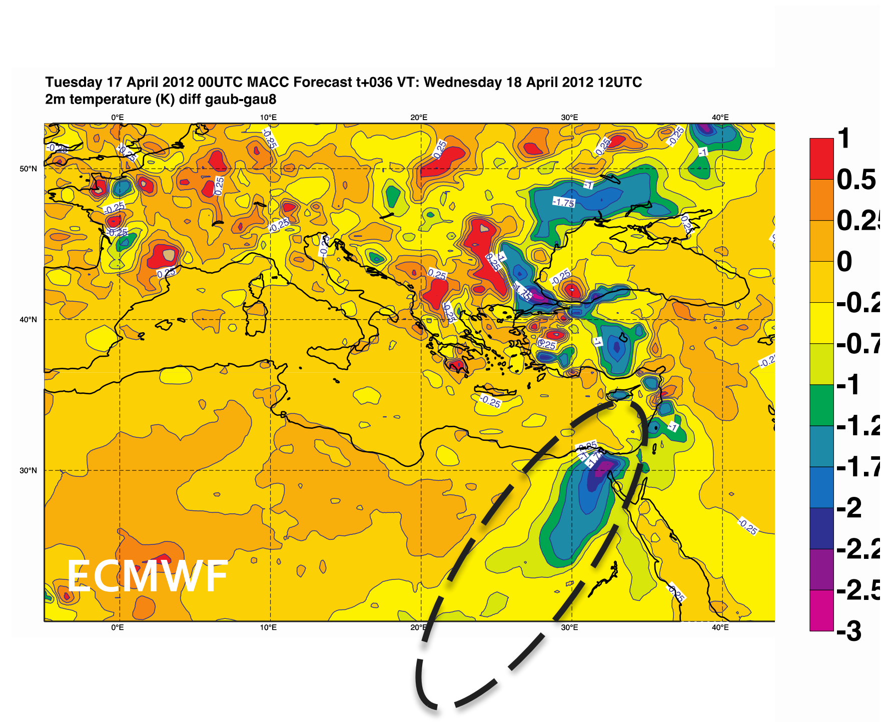
# DIFF of Temp @ 2-m
# AER-NOAER
## 12 UTC (morning)

**Location of the plume**

**Before**




**After bug fix**

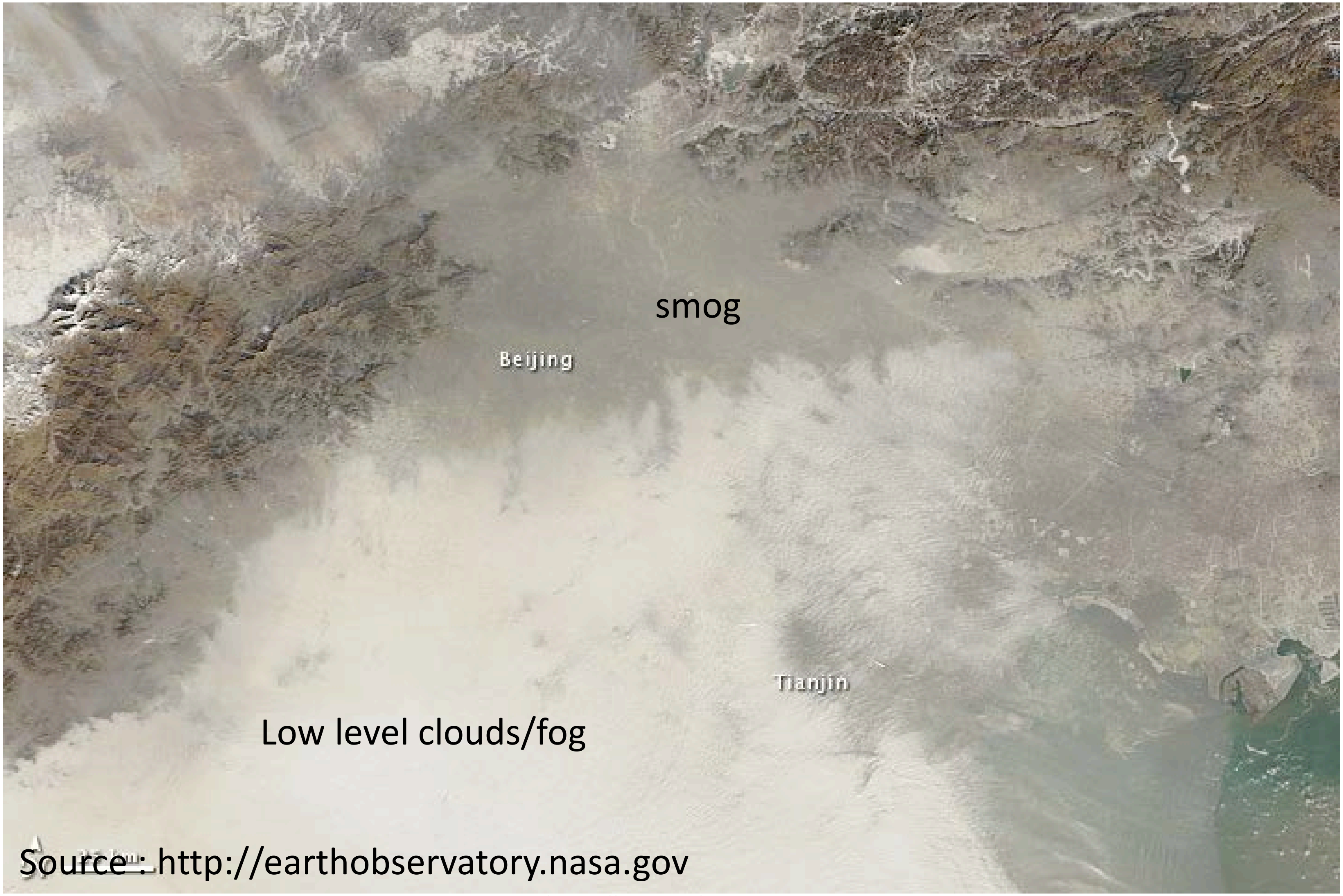


# Case 2
# Extreme Pollution in Beijing

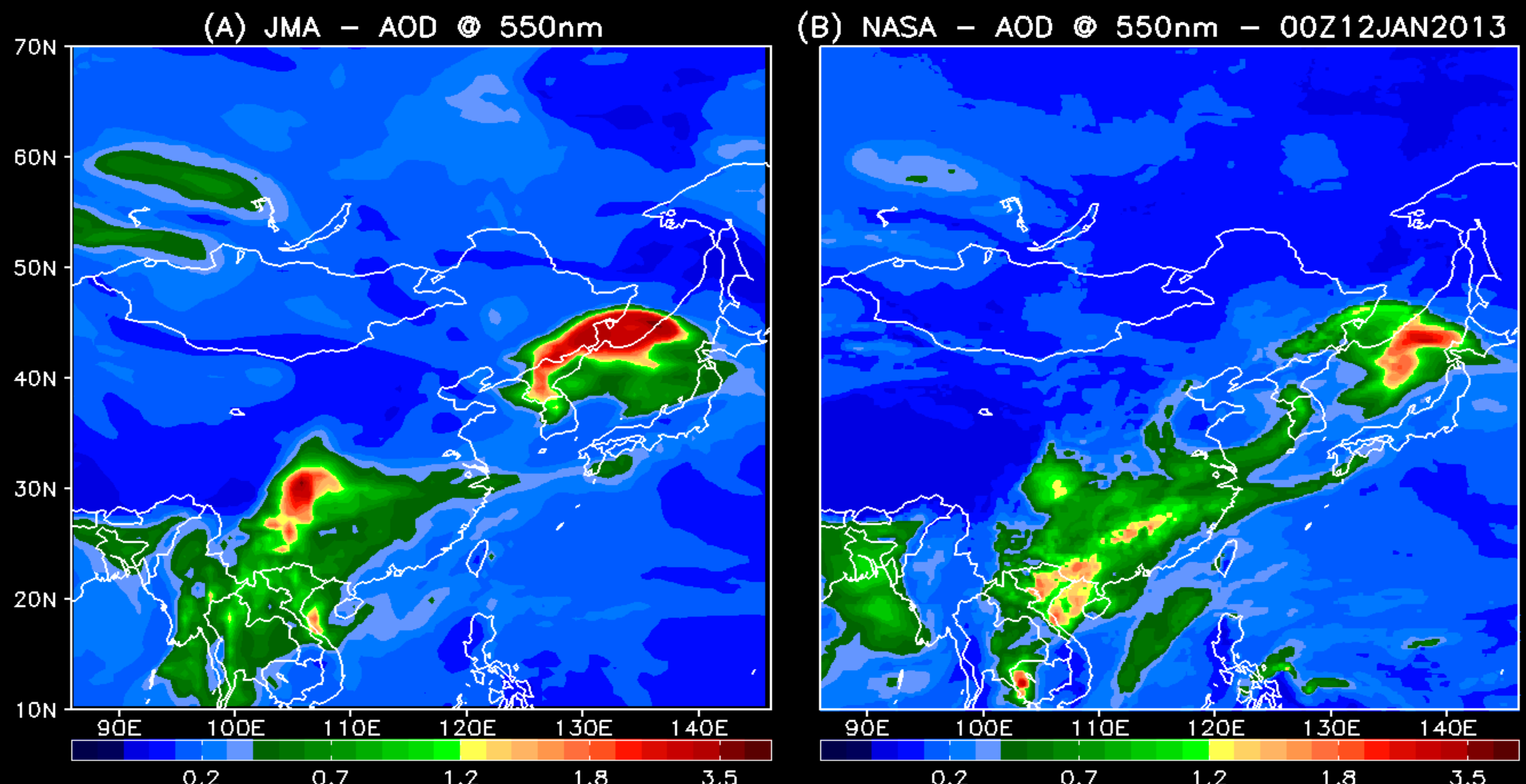
- January 2013
- Forecasts
  - January 7-21 2013
  - From 0 or 12 UTC
  - 10 day forecasts
- Center of domain
  - 116E, 40N
- Model configuration
  - Same as for NWP
- Direct & Indirect effects

So far, only JMA has submitted Indirect effect experiments.

# Case 2 – Urban Pollution

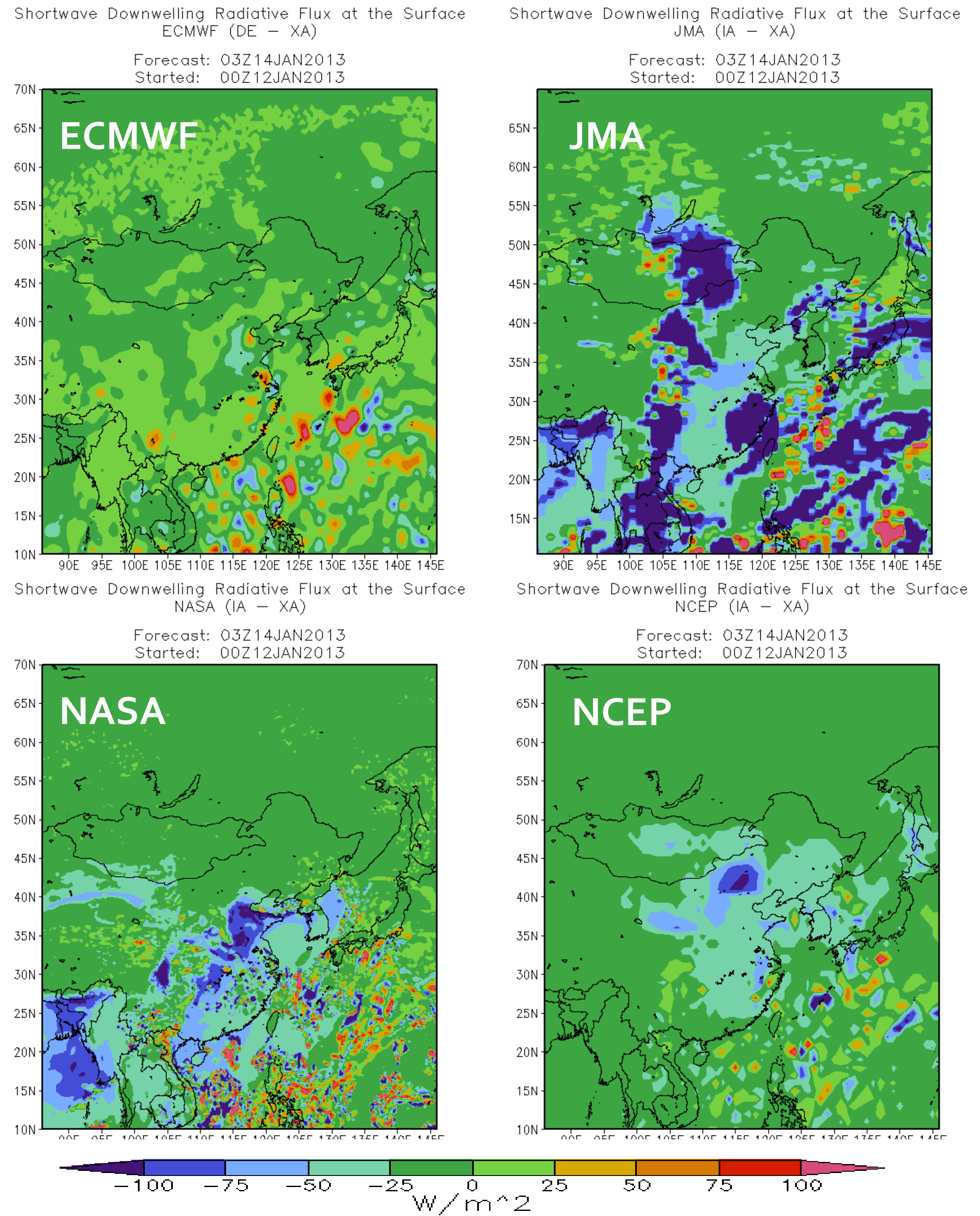


# Case 2: Pollution in China
# JMA & NASA Forecasts



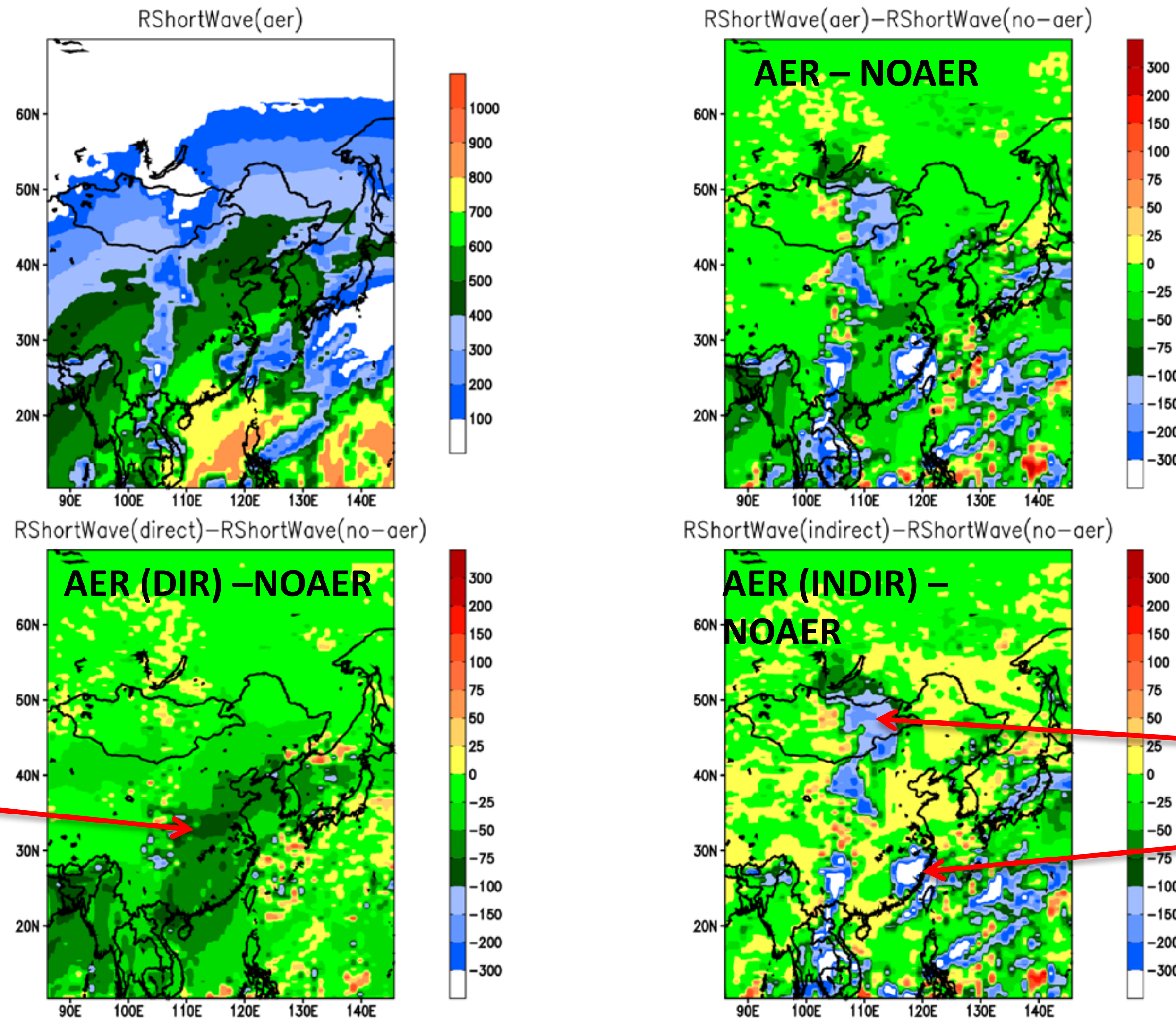
# SW Radiation @ Surface Impact (Aero-NoAero) 3 UTC 14 Jan 2013

- 3 UTC (day time)



# JMA – Rad shortwave at sfc (W m$^{-2}$)

## Init 00UTC12JAN FCT: 03UTC14JAN



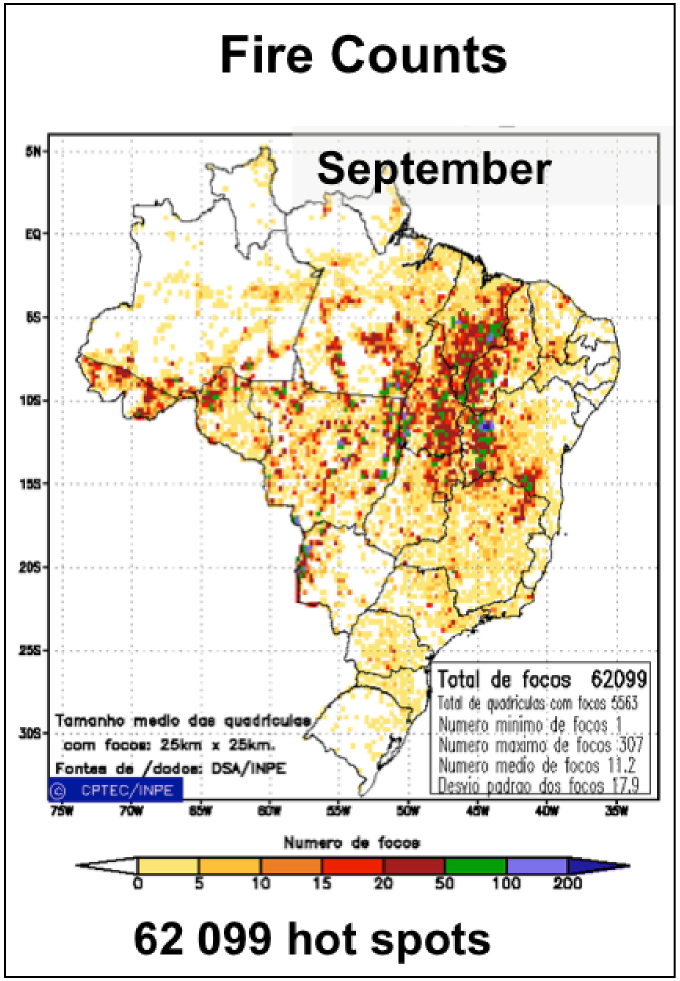

INDIR effect has more pronounced effect on sfc rsw extinction

DIR effect: -25 to -100 W m$^{-2}$

INDIR effect: -100 to -300 (or less) W m$^{-2}$

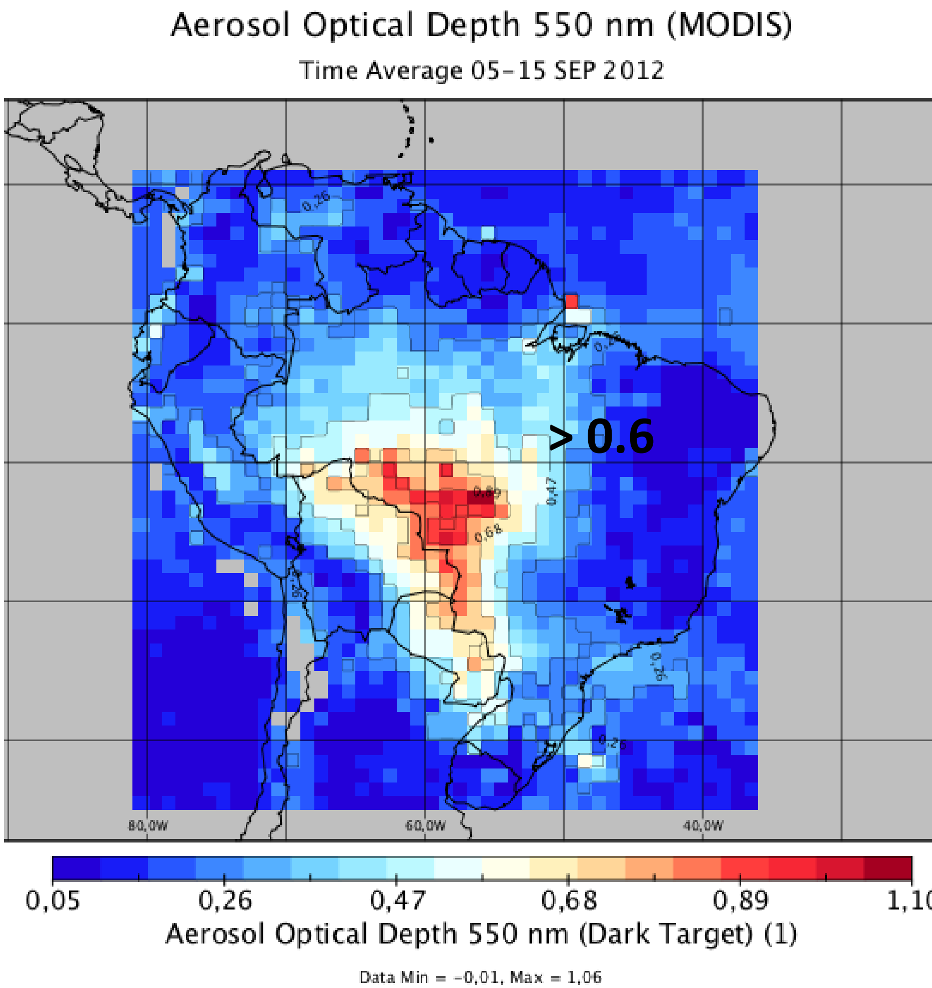
# Case 3
# Persistent Smoke in Brazil

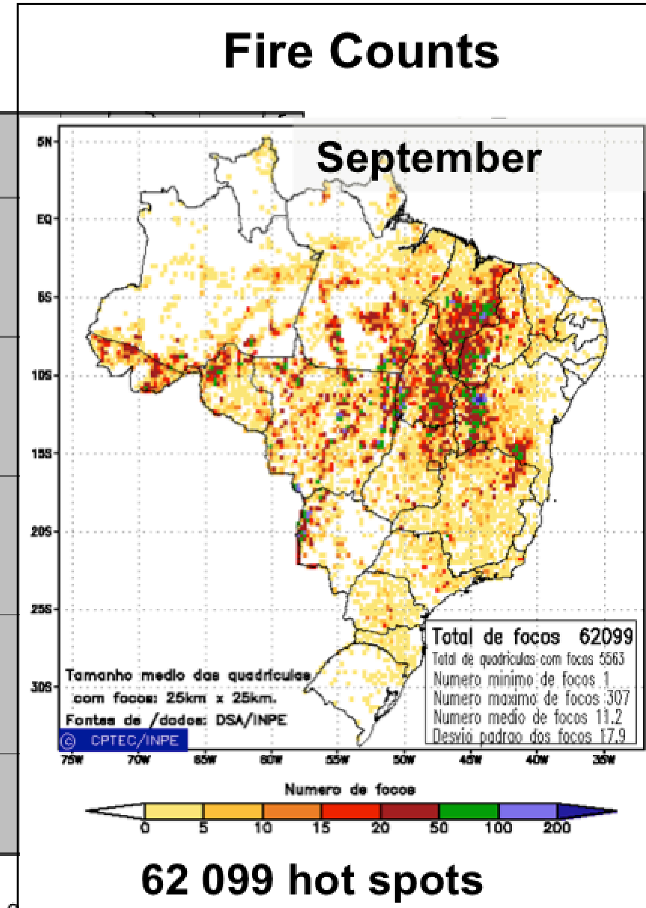
- September 2012
- Forecasts
  - September 5-15, 2012
  - From 0 or 12 UTC
  - 10 day forecasts
- Center of domain
  - 116E, 40N
- Model configuration
  - Same as for NWP
- Direct & Indirect effects



# Case 3- Persistent Smoke in Brazil

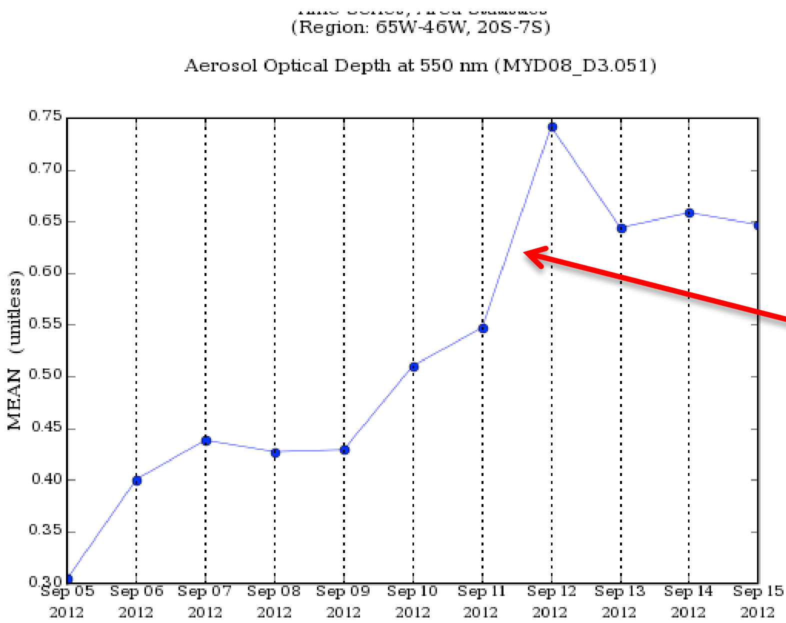
## MODIS AOD at 550 nm and Fire Counts (Sep 2012)

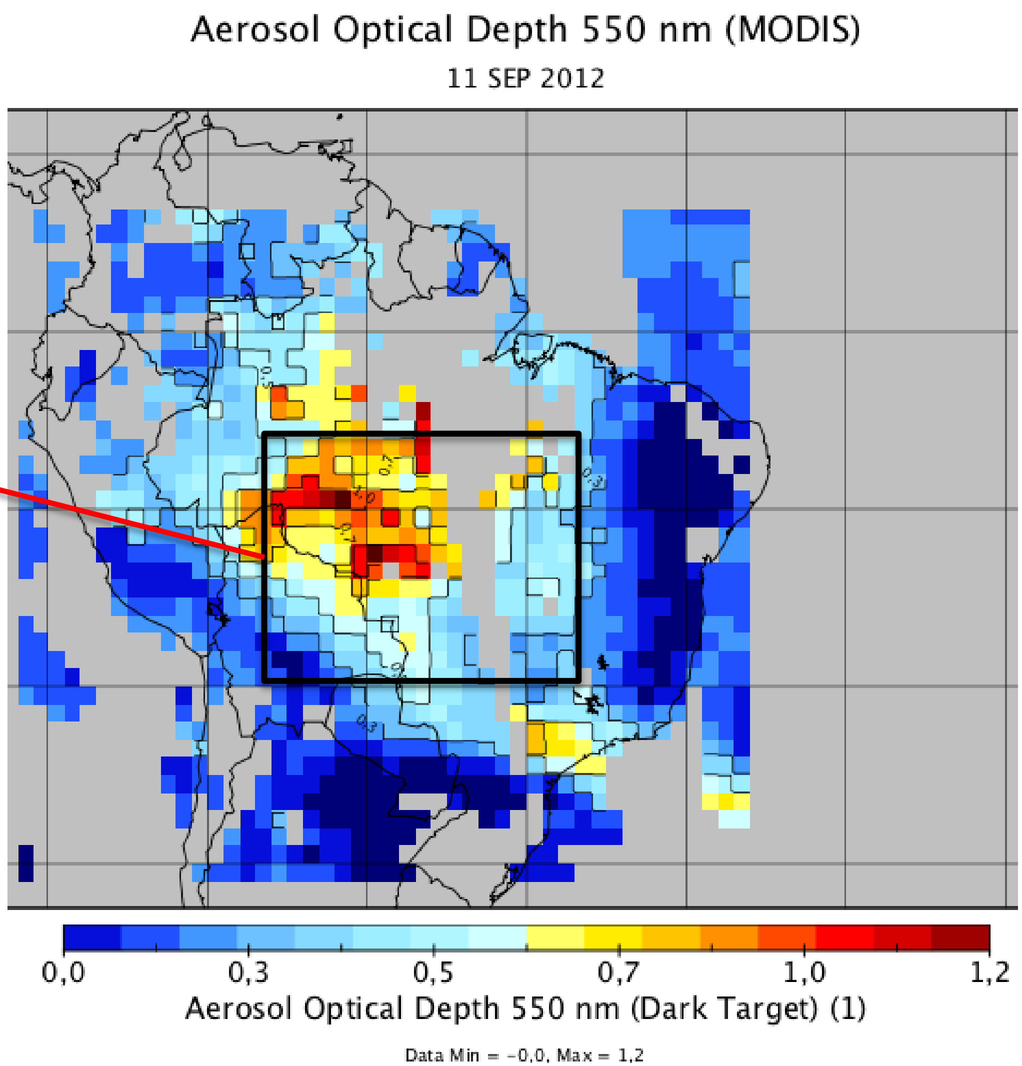


# Case 3- Persistent Smoke in Brazil

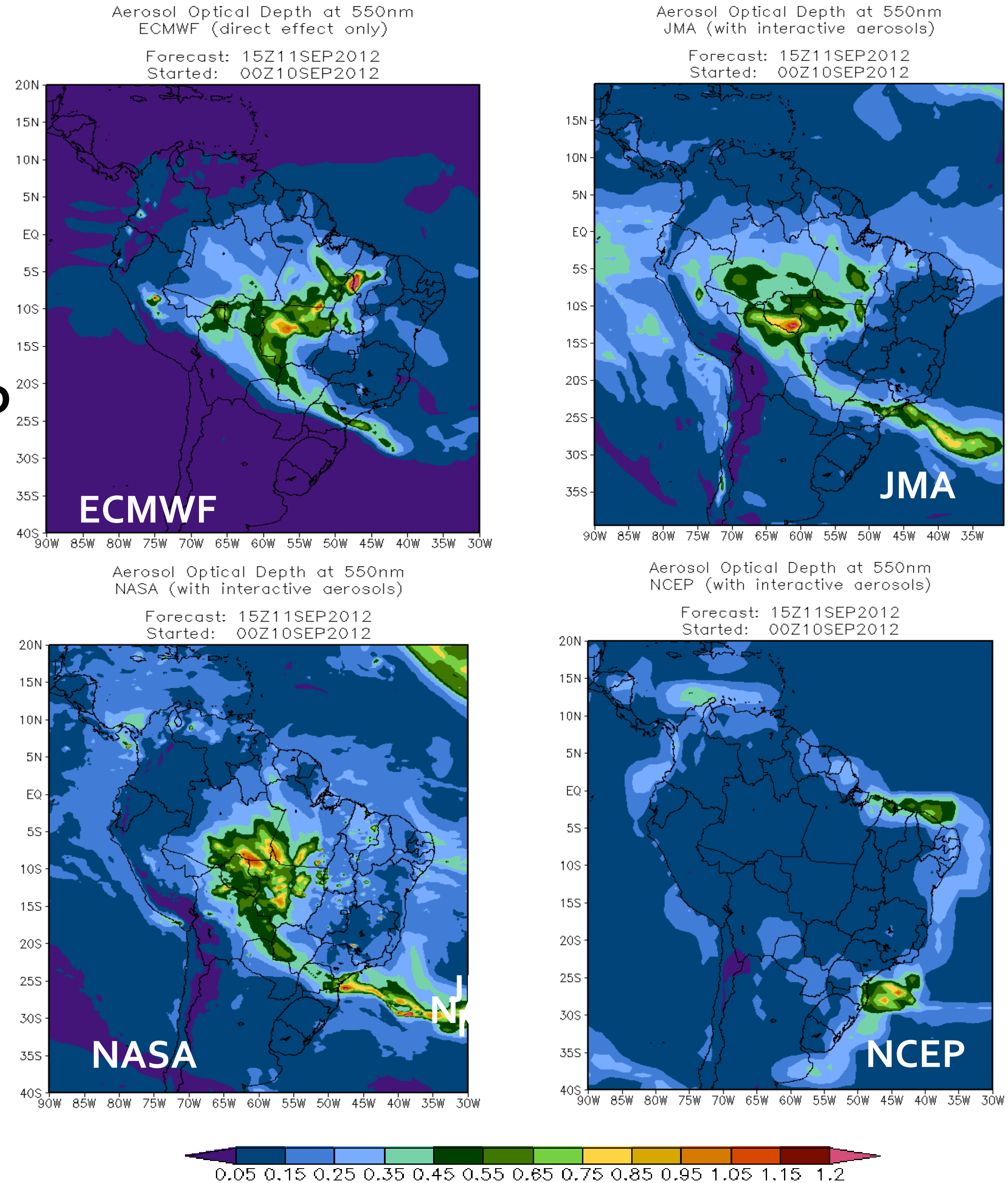
## MODIS AOD at 550 nm



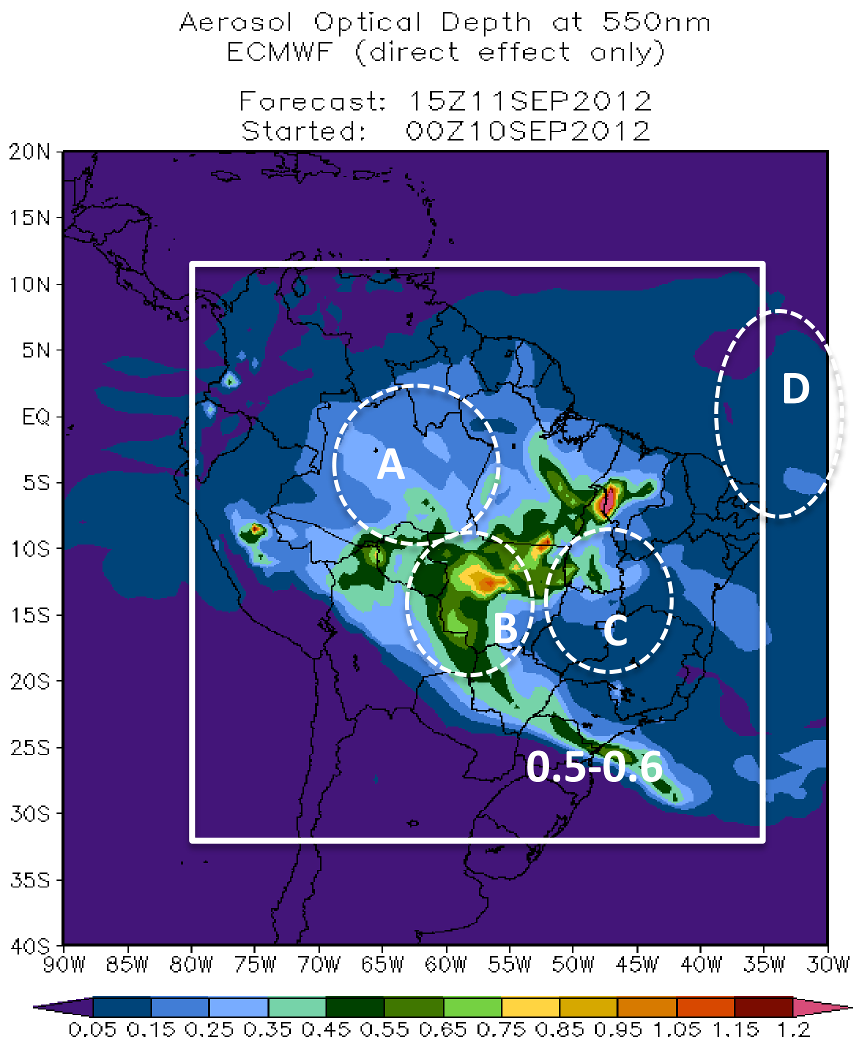
# AOD at 550 nm Forecast for 15UTC11SEP Init.: 00UTC10SEP

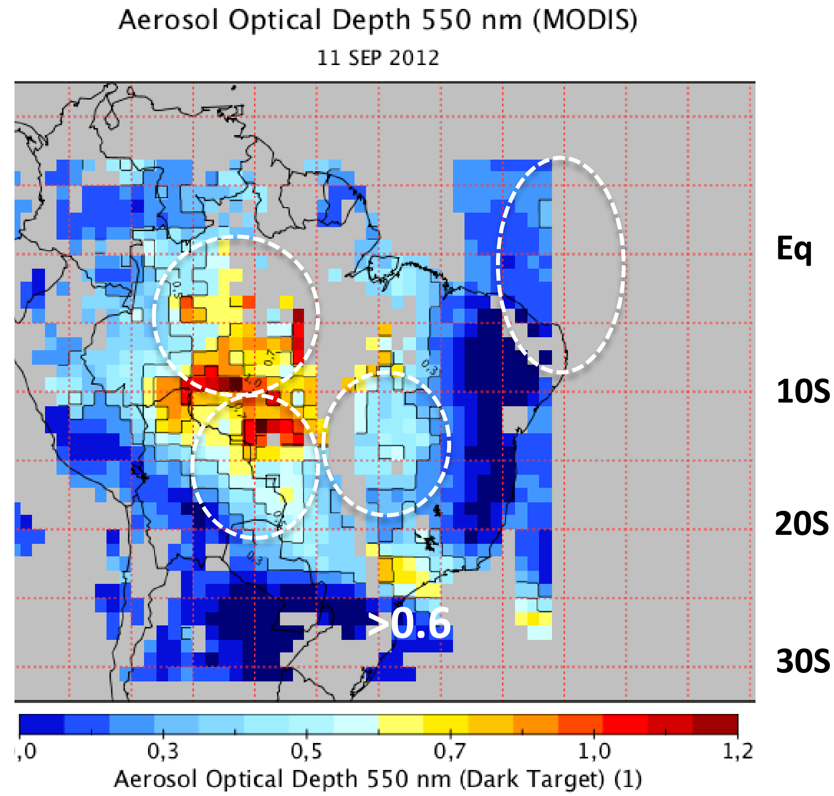
- 15 UTC (~noon)



# **ECMWF :** AOD at 550 nm

## Forecast for 15UTC11SEP - Init.: 00UTC10SEP

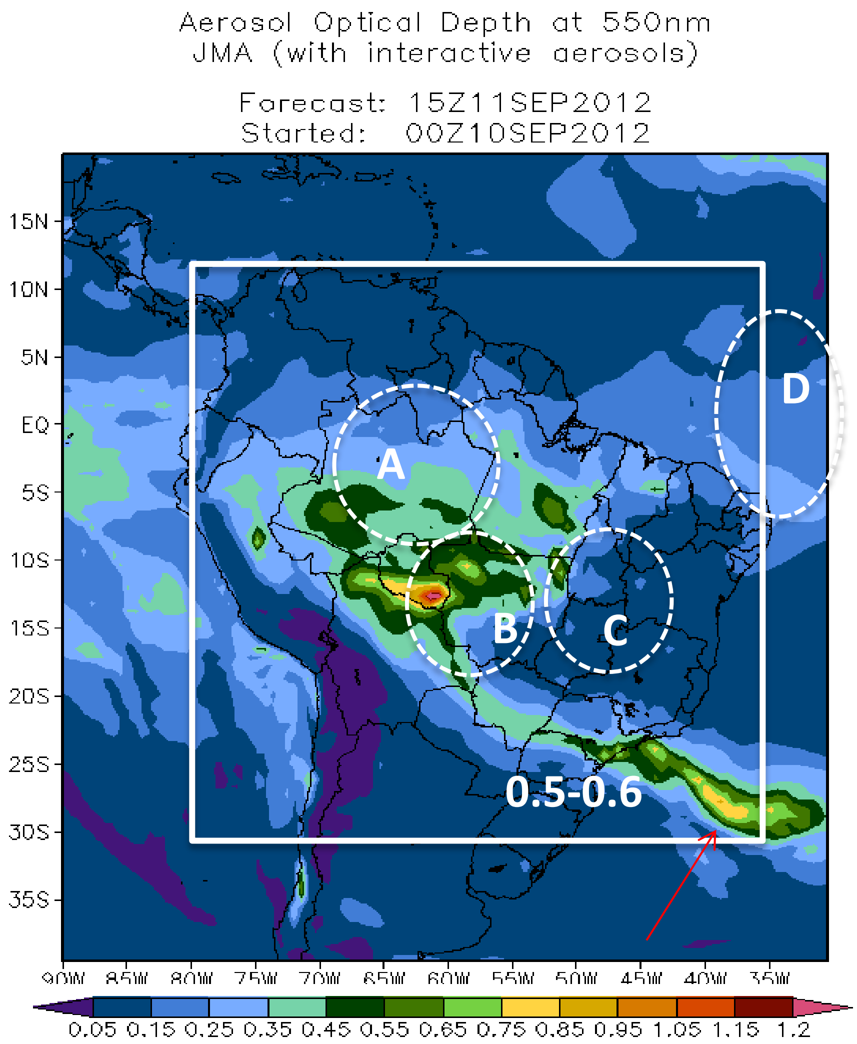


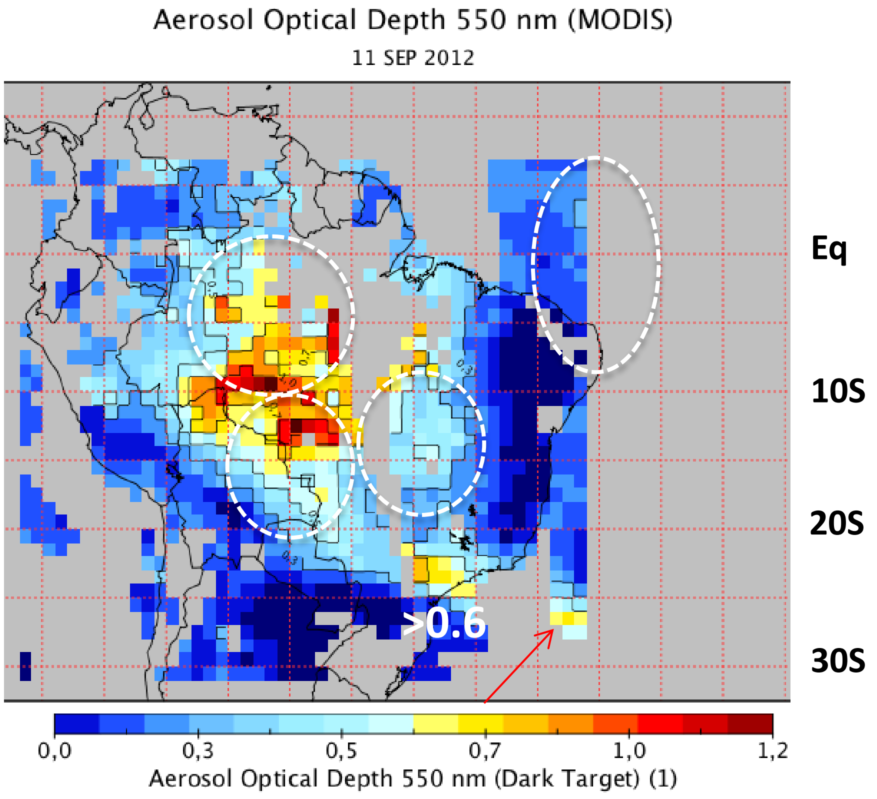




A: AOD is underestimated in the interior of Amazon basin (underwood fires?)
B: gradient from NW-SE is well represented, but with lower AOD
C: AOD is also underestimated (might be related to missing fires, savanna area)
D: Smoke inflow from African fires looks also underestimated
E: SE outflow looks fine (mag and location)

# **JMA :** AOD at 550 nm

## Forecast for 15UTC11SEP - Init.: 00UTC10SEP

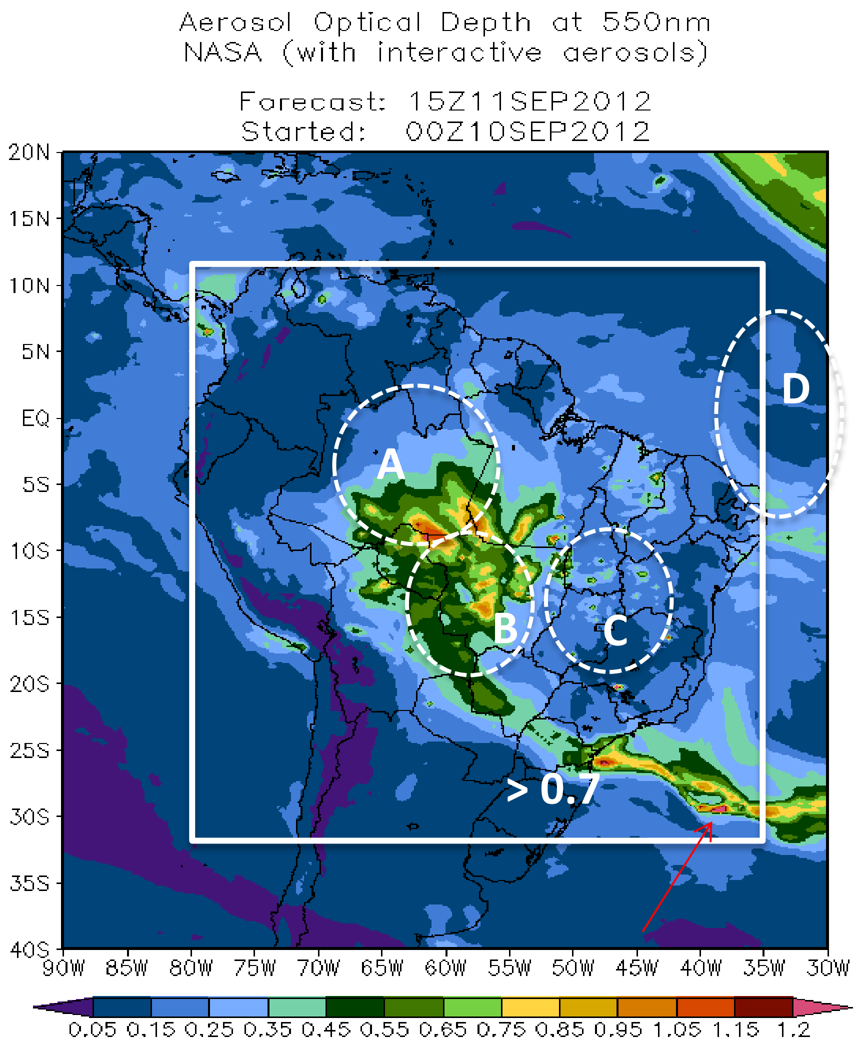


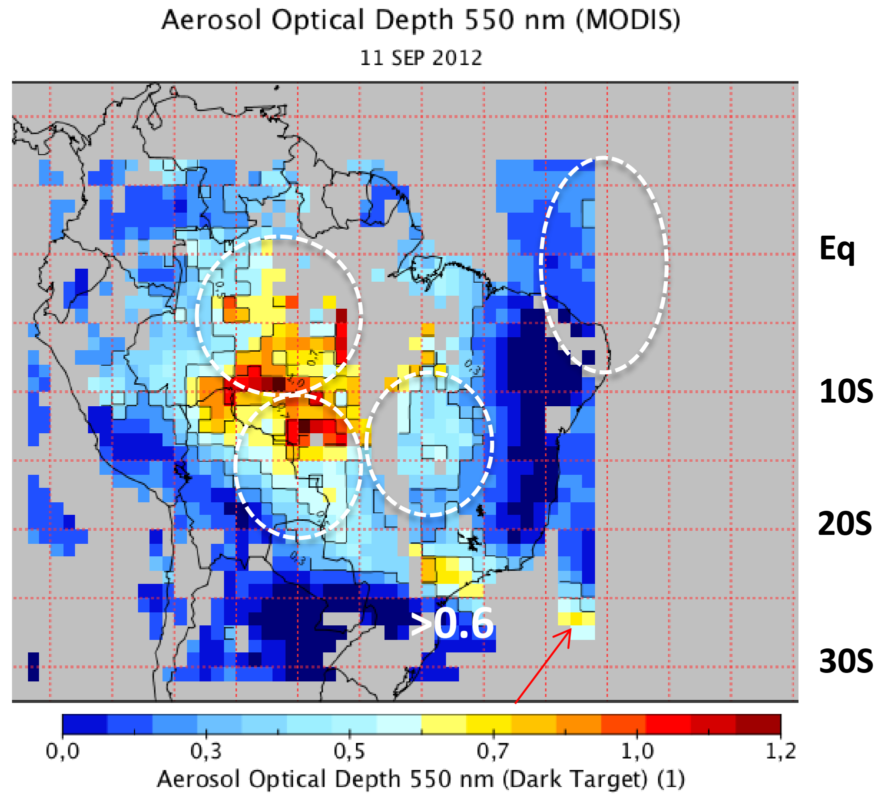




A: AOD is underestimated in the interior of Amazon basin (underwood fires?)
B: gradient from NW-SE is well represented, but with lower AOD
C: AOD has the larger underestimation
D: Smoke inflow from African fires looks fine
E: SE outflow looks fine (mag and location)

# NASA : AOD at 550 nm

## Forecast for 15UTC11SEP - Init.: 00UTC10SEP




A: AOD is better represented in the interior of Amazon basin

B: gradient from NW-SE is well represented, but with lower AOD

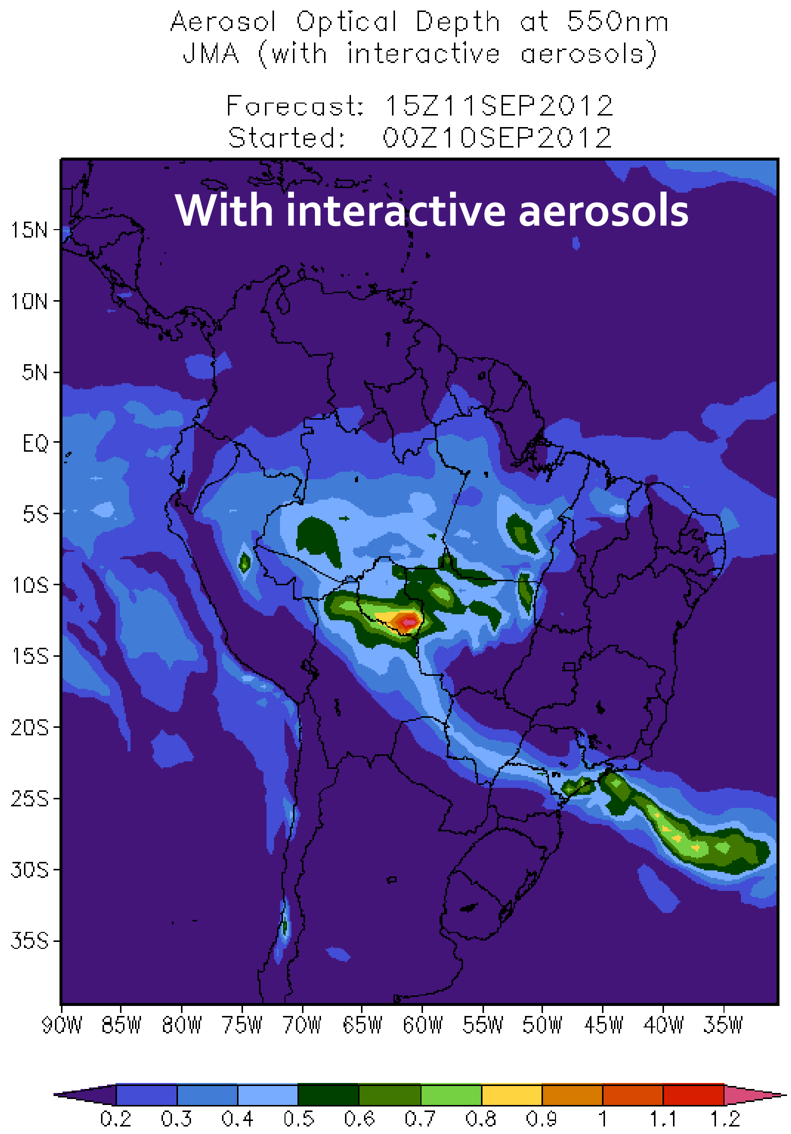
C: AOD is also underestimated (might be related to missing fires, savanna area)

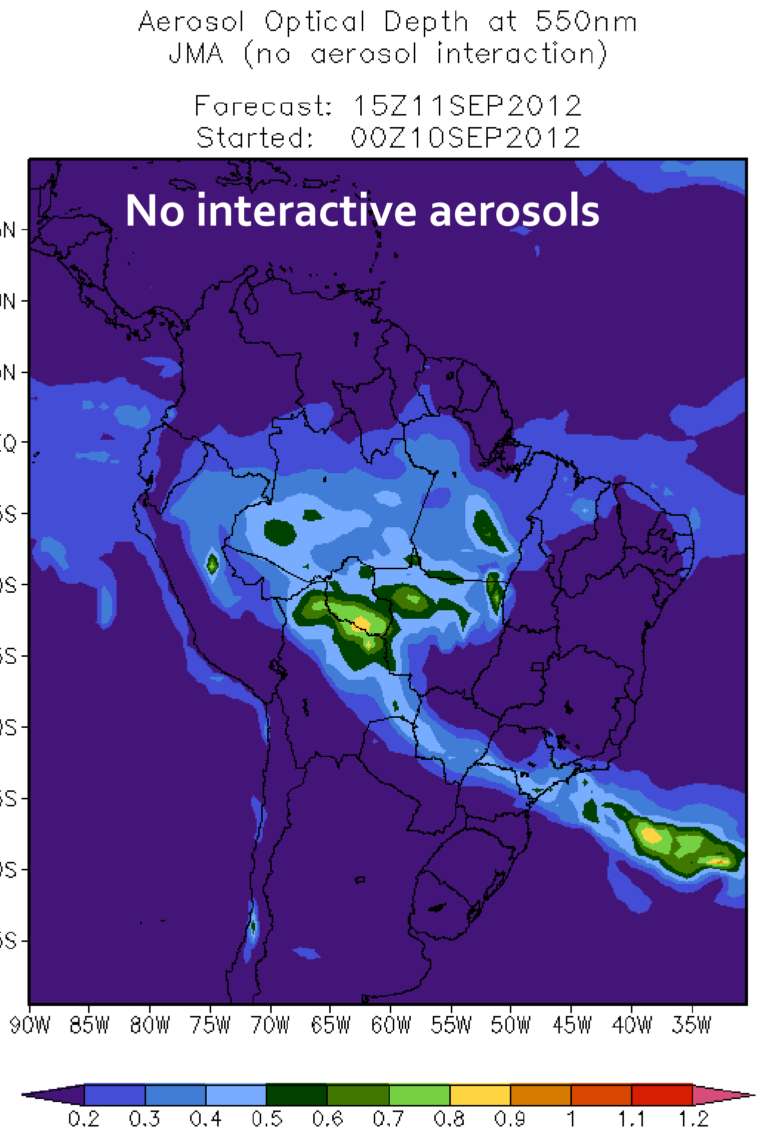
D: Smoke inflow from African fires looks better represented

E: SE outflow looks fine (mag and location)

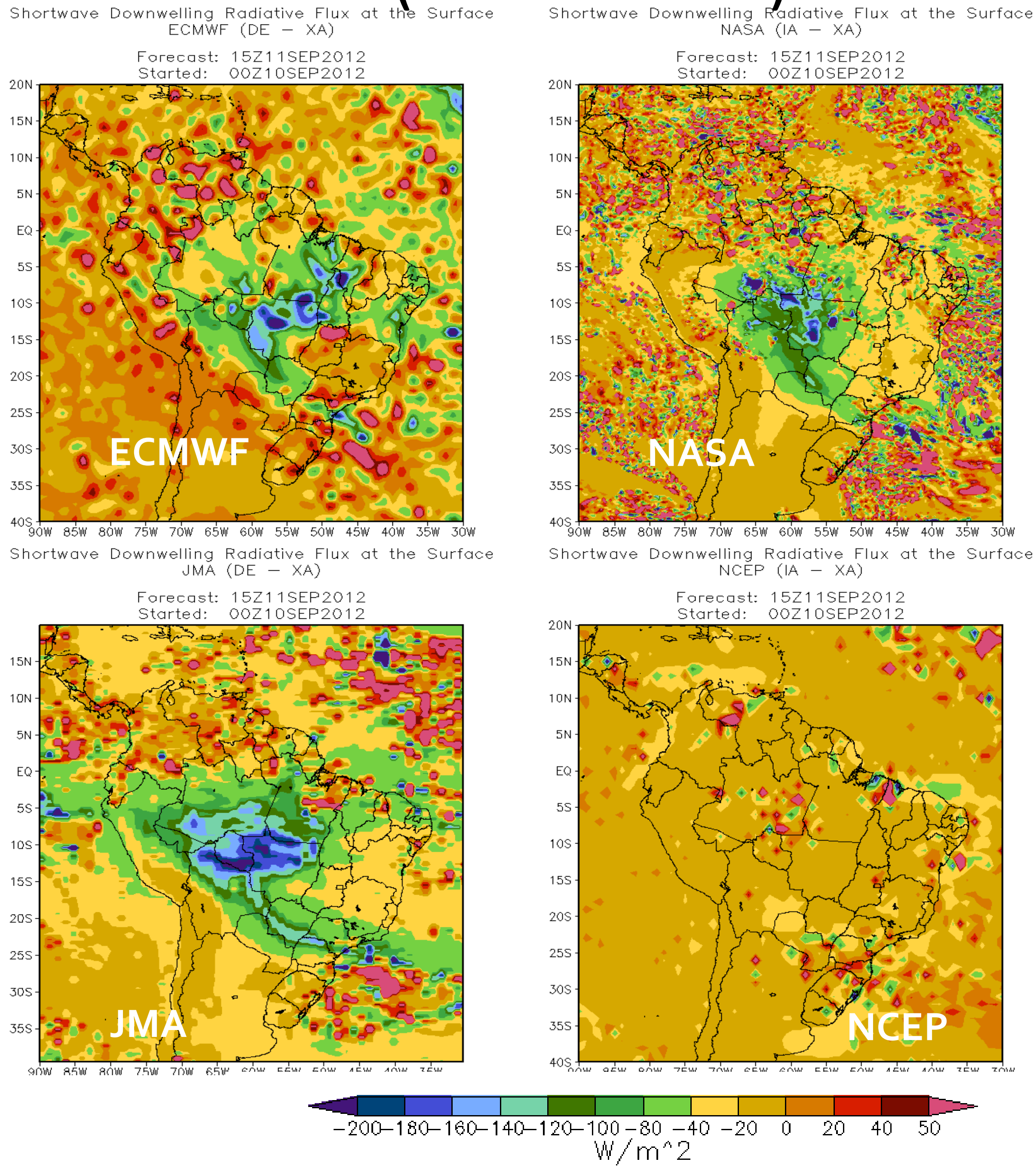
# AOD @550 nm Forecast from JMA model

## Forecast 15UTC11SEP - Init.:00UTC10sep



# SW down Radiative Flux (AER-NOAER)

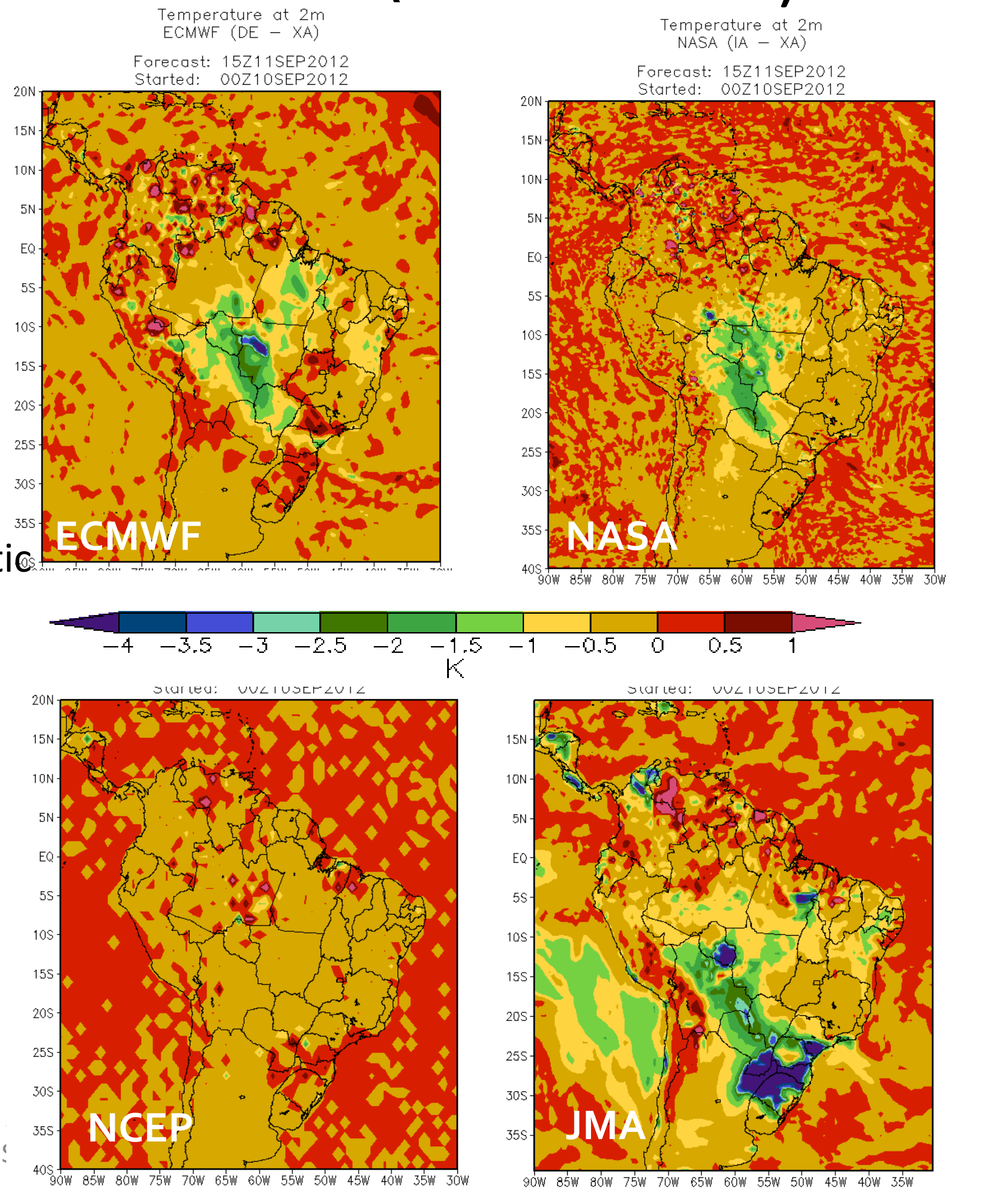



Forecast for 15UTC11SEP - Init.:00UTC10SEP

- Direct effect can produce a reduction of up to ~ 200 W/m$^2$ when using prognostic aerosols
- The use of climatological data implies on much lower impact.

# 2-m Temperature Difference (AER-NOAER)

Forecast for 15UTC11SEP
- Init.:00UTC10SEP



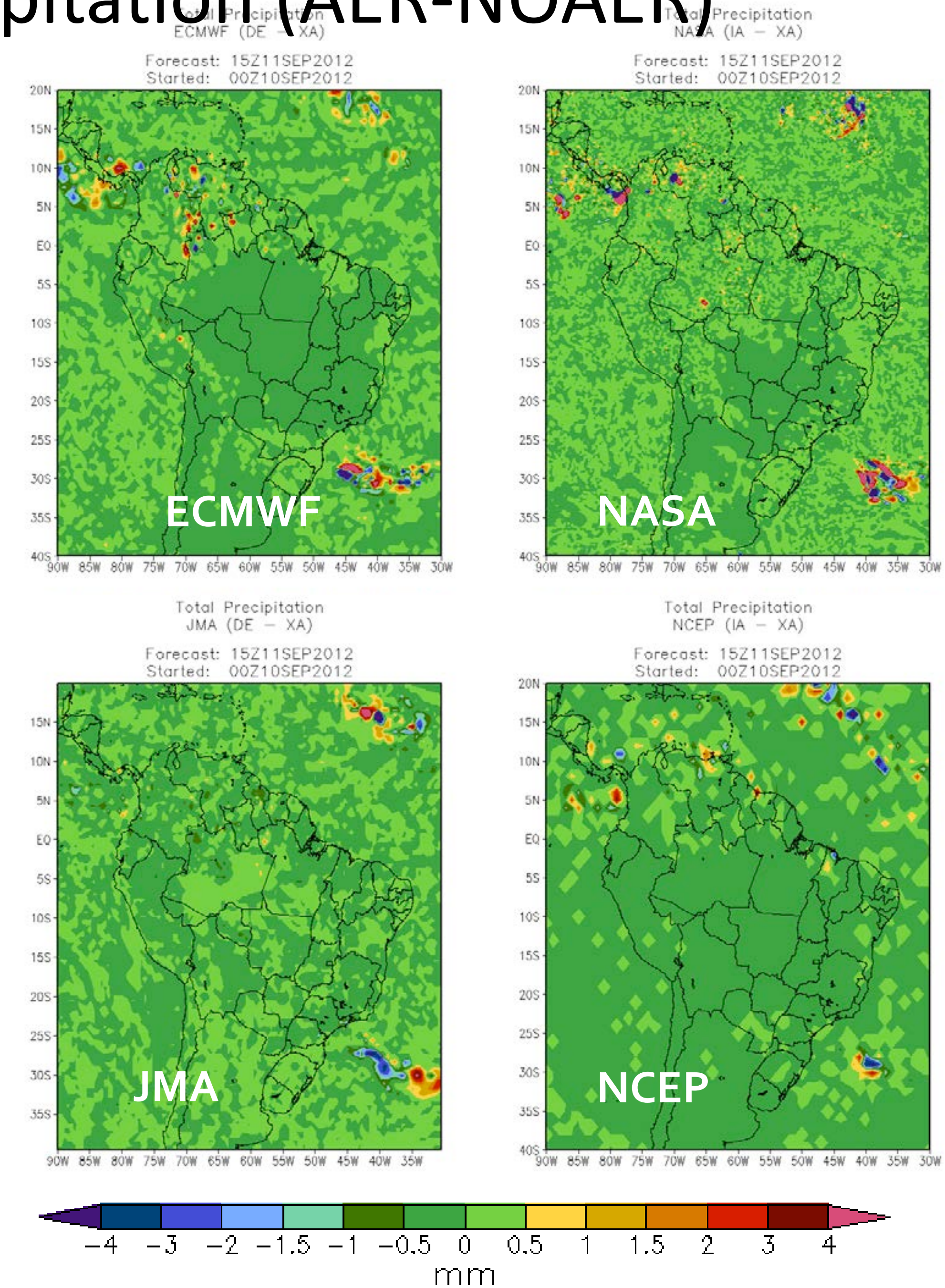

- Direct effect can produce cooling of up to ~ 4 K when using prognostic aerosols
- Indirect effect can even produce larger reduction on T2m
- The use of climatological data implies on less cooling.

WGNE
US

# Grid-scale Precipitation (AER-NOAER)

Forecast for 15UTC11SEP - Init.:00UTC10SEP

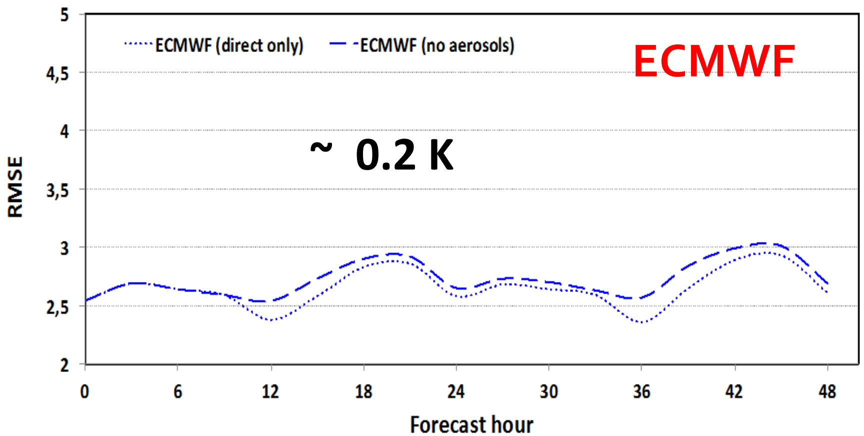
- The differences are related to the clouds position only.
- The same holds for convective precip.

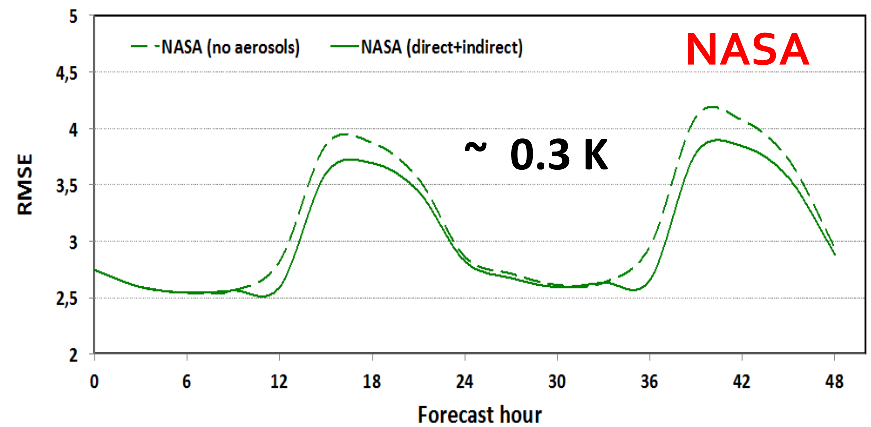


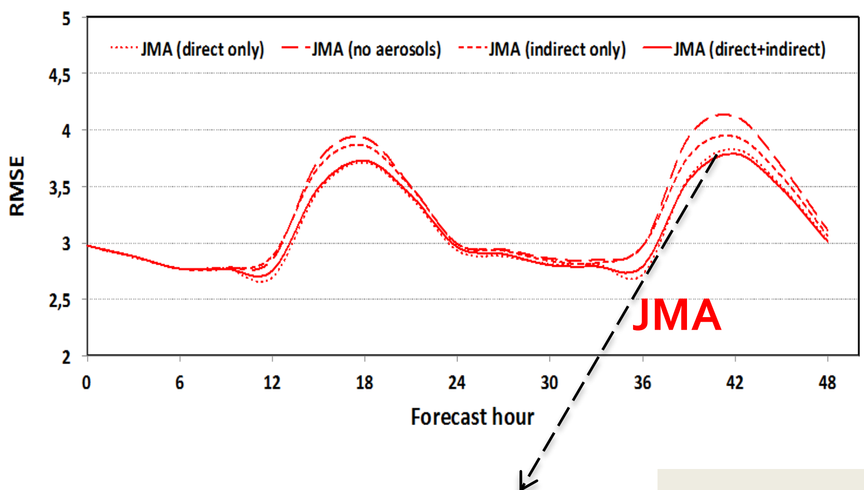
# Preliminary quantitative evaluation for the SAMBBA case

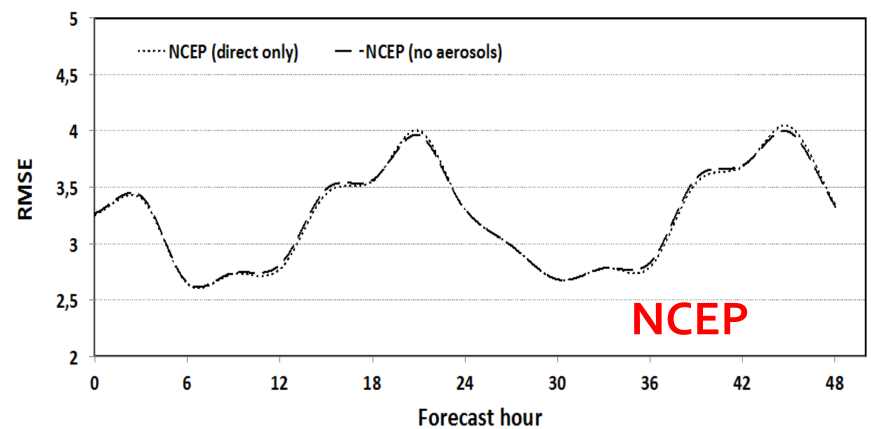
- Parameter: 2-meter temperature.
- Observational data: up to 1200 meteo surface stations over S. America.
- Interpolation method: nearest neighbored.
- Analyzed time period: 5 – 14 SEP, up to 48 hours forecast.

# RMSE: 2-m Temperature



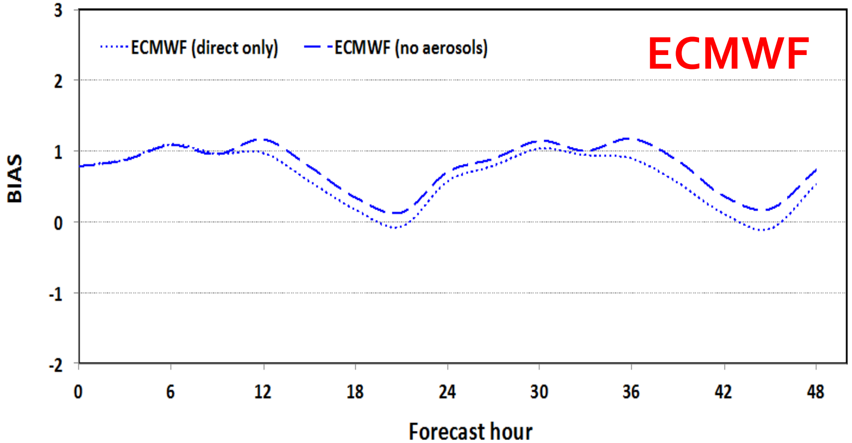




**4.12 – no interaction**
**3.94 – indirect only**
**3.83 – direct only**
**3.79 – IND + DIR**

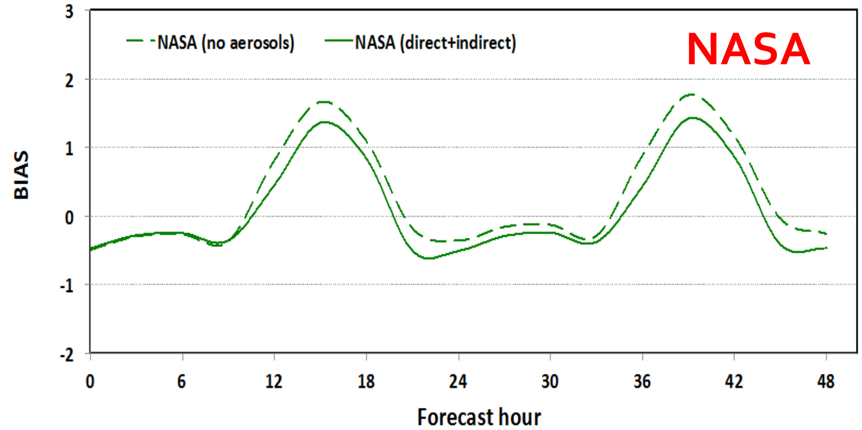
- ECMWF, NASA, JMA: Consistent and significative RMSE reduction
- NCEP : negligible change
- JMA : RMSE reduction increases with the aerosol treatment complexity

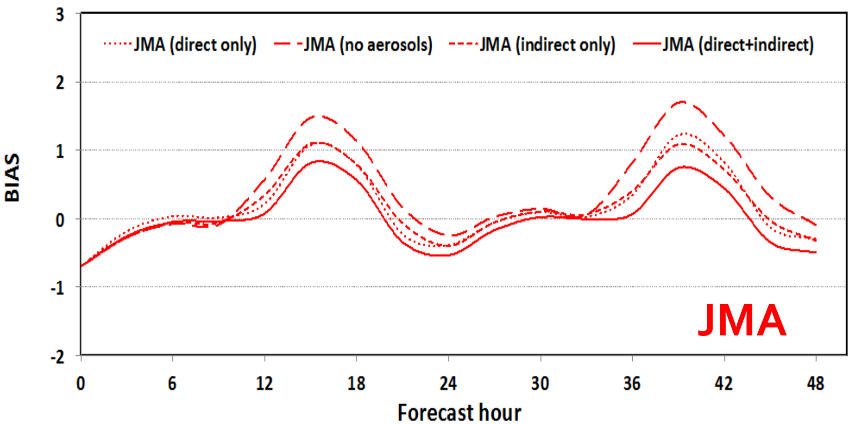
# BIAS: 2-m Temperature

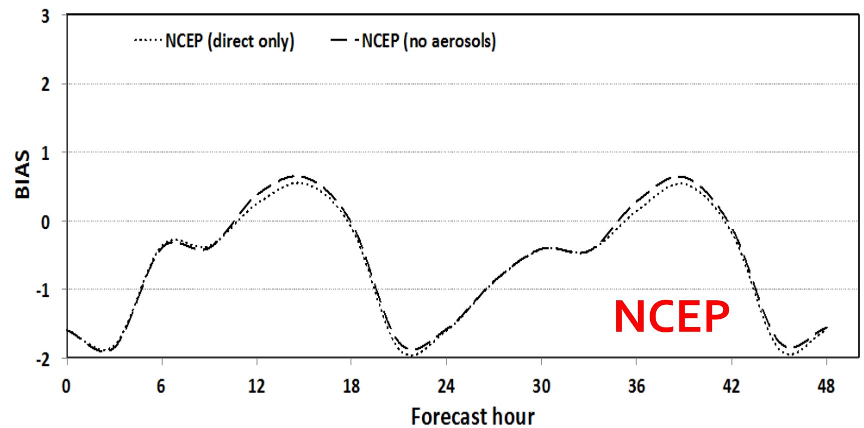
Consistent bias reduction




Bias decreases during the day, but increases at night



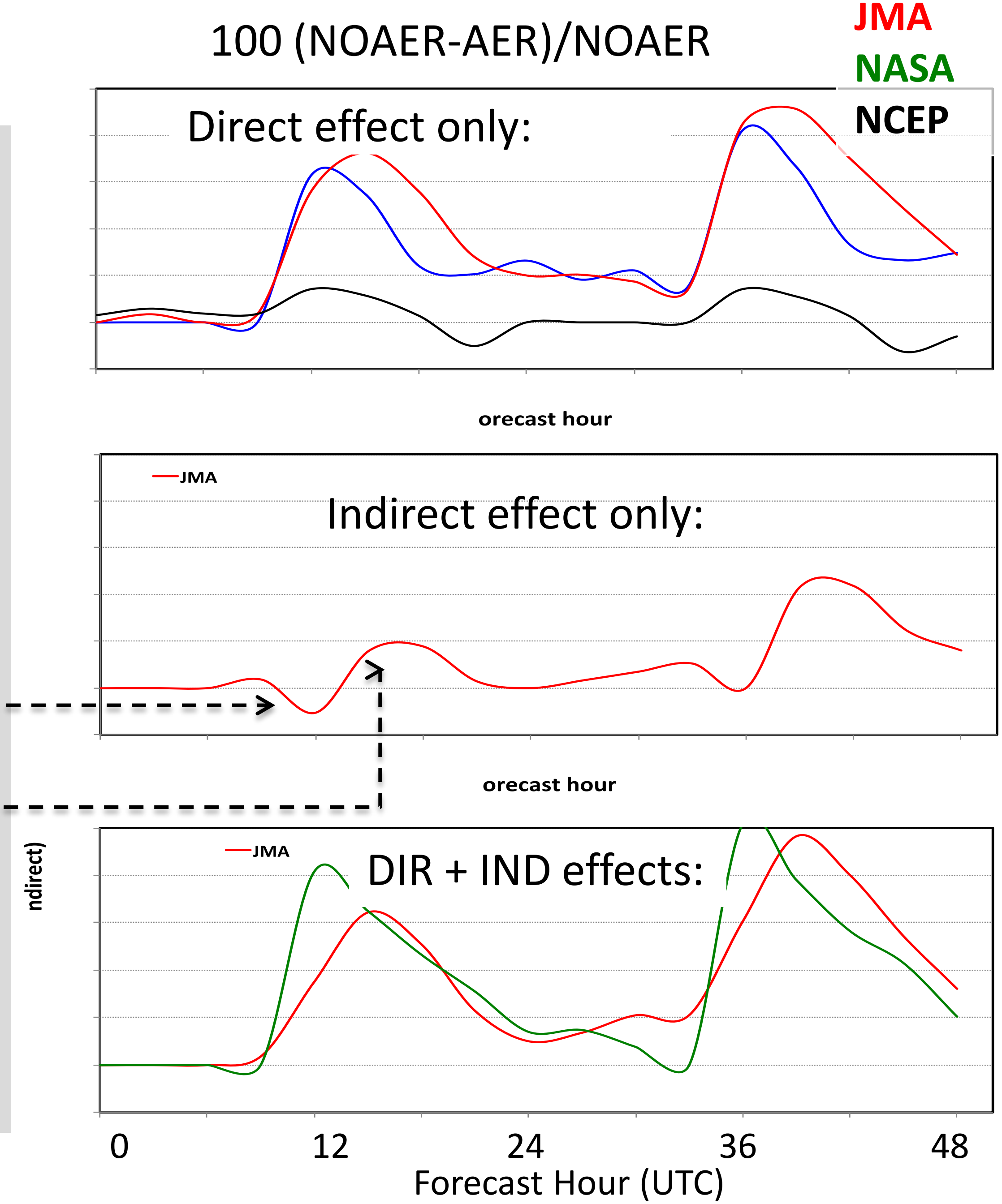




Consistent bias reduction with increasing aerosol treatment complexity during the day, with a slight increase during the night.

Slight decrease of bias during 12-18 UTC

# Relative Variation of RMSE

- prognostic/interactive aerosol can improve RMSE up to 10%.
- For this case (dry season), direct effect has the larger impact on the improvement.
- Indirect effect imposes an initial deleterious RMSE increase in morning
- but further improvement on afternoon.
- Perhaps, this indicates a misrepresentation of the diurnal cycle of convection?



# Ongoing work at NOAA/ESRL

- Georg Grell's group is applying WRF-Chem model for SAMBBA and Beijing cases
- WRF-Chem 3.6.1 version
  - 590 * 420 grid cells @ 15km resolution (similar for 5km resolution runs), 50 vertically stretched levels
  - 1-way nested domain with 5km resolution, similar number of grid points
  - ERA Interim Daily meteorological data
  - MACC reanalysis data – Boundary and Input conditions
  - MEGAN biogenic emissions, EDGAR & RETRO anthropogenic emissions, MODIS & WF-ABBA Fire emissions
  - For full chemistry run: Modal aerosols, gas-phase chemistry (RACM), aqueous phase chemistry (aqchem, and transport of all aqueous phase species)
  - RRTMG short and long wave radiation
  - Morrison double moment microphysics
  - GF for convection, one run with aerosol awareness turned on, always scale-aware, also used on 5km resolution domains

# Some initial thoughts and Planned Methodology

① **Aerosol impacts on NWP**: Use sophisticated cloud resolving simulations, then decrease complexity and resolution (15, 5 and 1.7 km) to what is used in operational systems.

② How different are simple, lower resolution simulations from complex simulations? Observations?

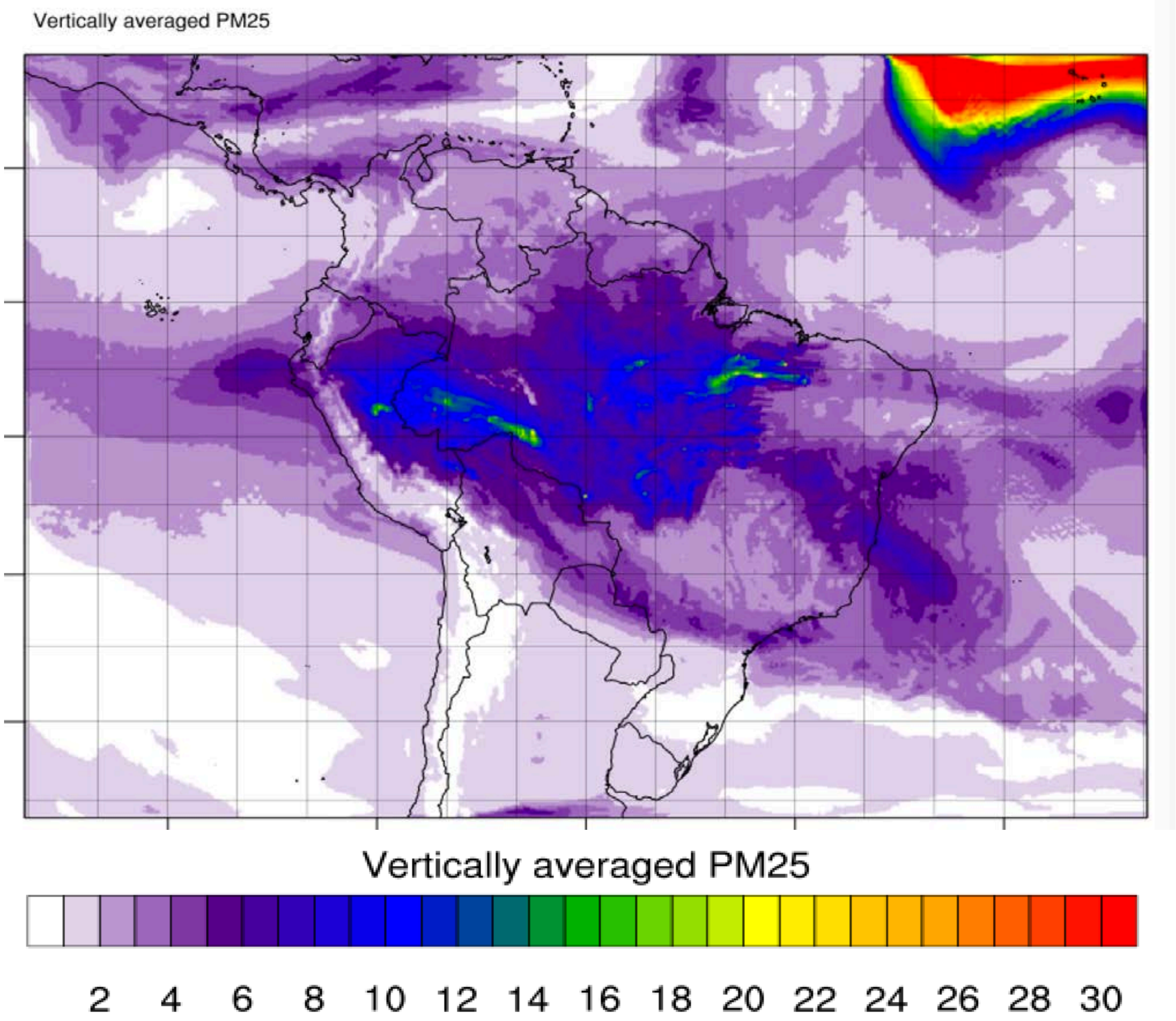
③ Many studies of indirect effect use resolutions that require **convective parameterizations**. Unless the CP includes aerosol interactions, conclusions are at best suspect.

④ Conclusions are also suspect with a CP that includes aerosol interactions – unless we can show agreement with cloud resolving simulations



Slide provided by G. Grell

# Typical vertically averaged PM2.5 distribution





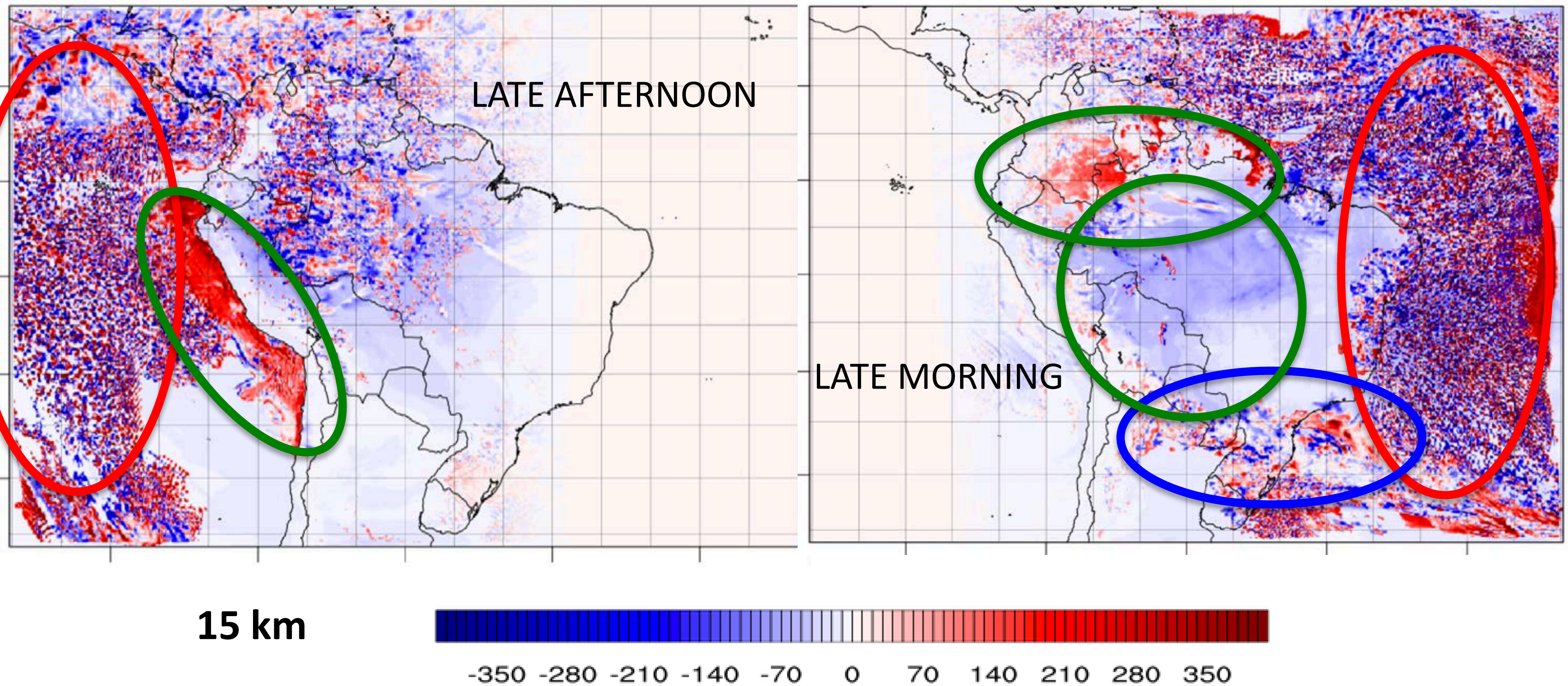

Slide provided by G. Grell

# Systematic and random SW differences (Chem – Met) (almost every run, 20 runs, 3-day forecasts) (AER – NOAER )

Random changes, caused by different location of clouds, not ... in the point

Systematic changes in almost every run

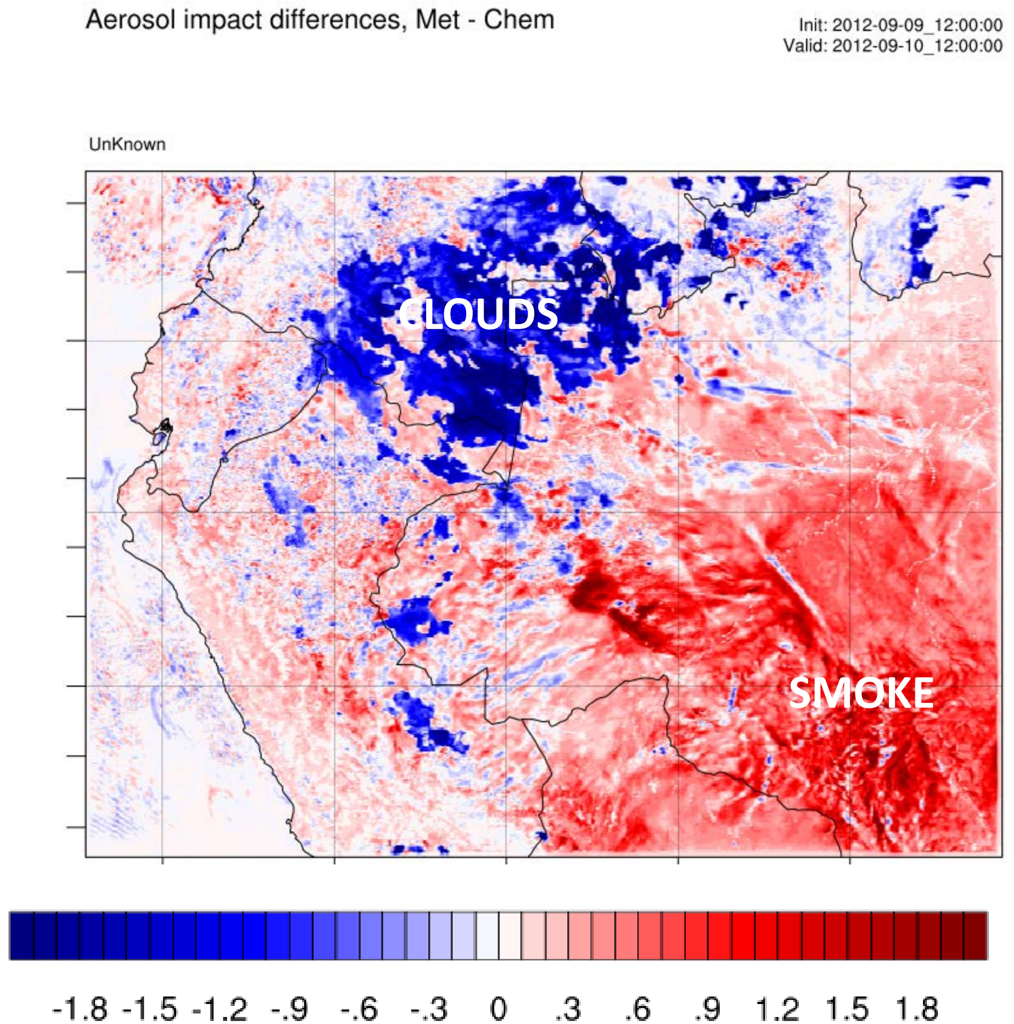
... increasing the aerosol concentrations






Slide provided by G. Grell

# First results from 5km resolution simulation, T2m differences, MET-CHEM (NOAER –AER)




**5 km**

Warmer



Slide provided by G. Grell

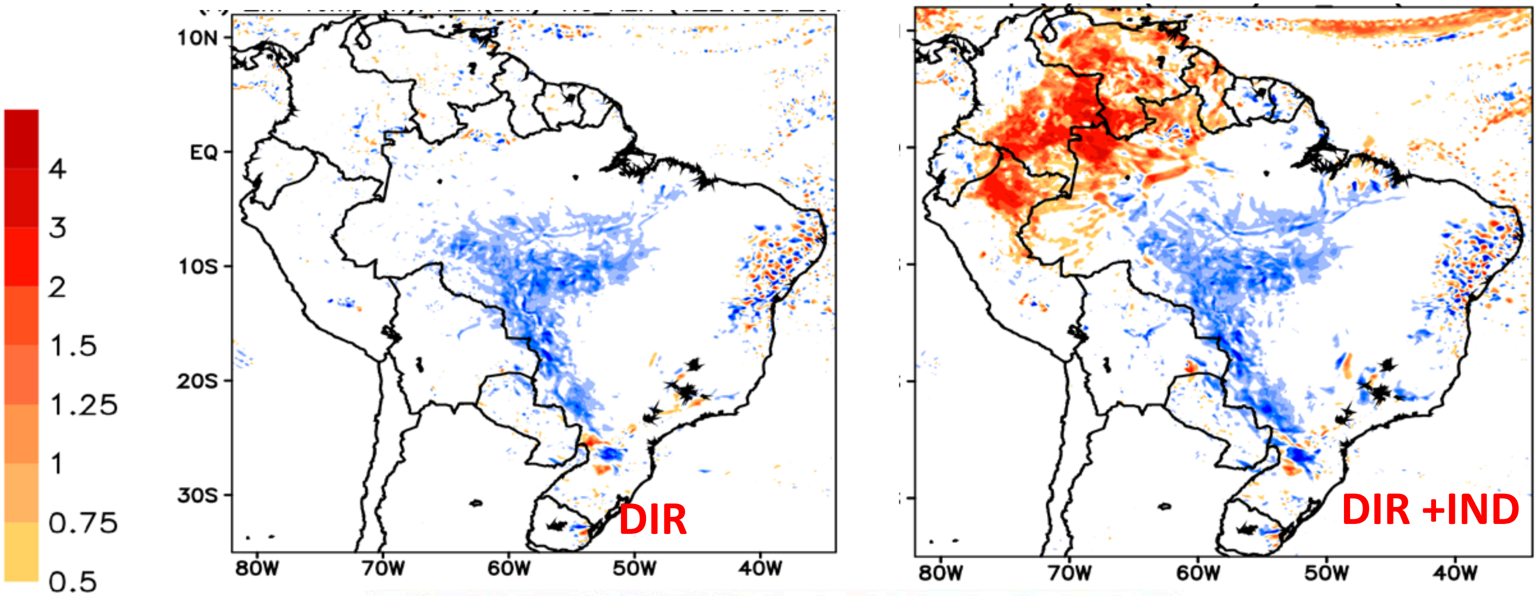
**So what happens if you try this with aerosol-awareness turned on in the GF convective parameterization?**

First run with dx=15km, Sep 9, 12Z initialization

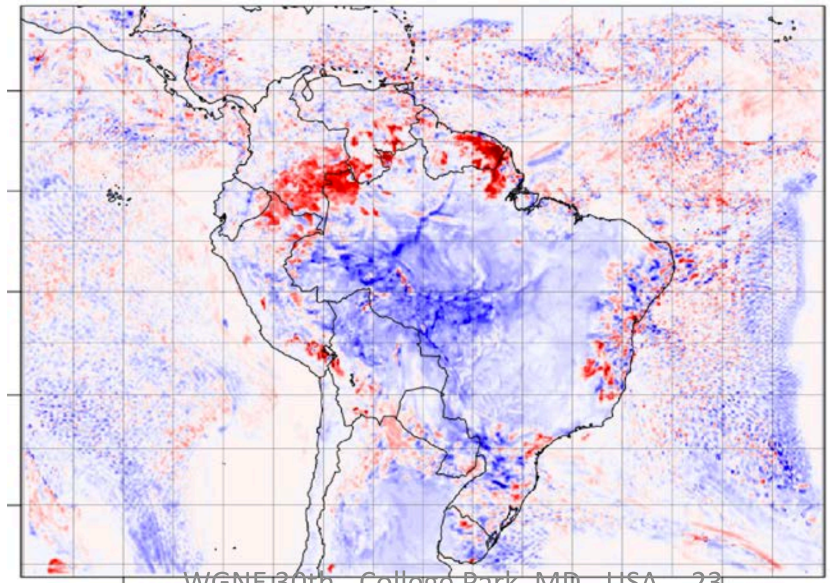


Slide provided by G. Grell

**T2M difference fields, September 10, 1200UTC- mid-morning. Positive (red) is warmer compared to MET – simulation with convective parameterization**




**15km**



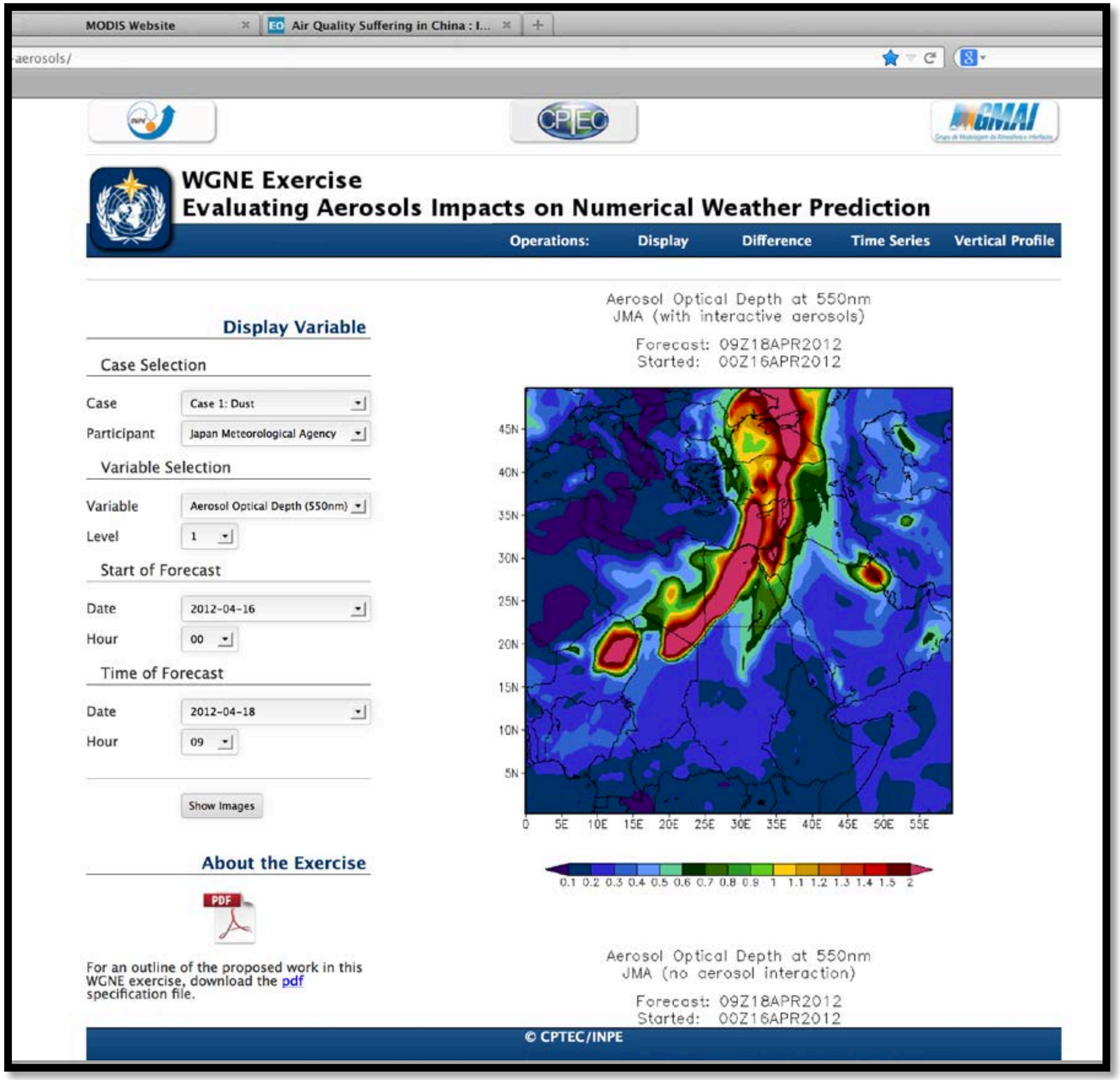
**5km (~ Cloud resolving simulation)**



Slide provided by G. Grell

# Analyzing the data with GrADS Online

Webpage hosted by CPTEC/Brazil for data analyzing and visualization
http://meioambiente.cptec.inpe.br/wgne-aerosols/






Developed by M. Zarzur

# Current status of observational data

| Case | Surface* | Radiosonde | TRMM | Merge | MODIS/ AERONET AOD |
|---|---|---|---|---|---|
| Case 1 | ** | | | | X |
| Case 2 | CMA | CMA | | | X |
| Case 3 | CPTEC | CPTEC | CPTEC | CPTEC | X |

X – data set has already been downloaded

X – data set is available but has yet to be downloaded

- *Pressure, temp, dew-point temp, wind, AOD, PM2.5, 24-h accumulated rainfall
- **Will Contact S. Remy (ECMWF) for sharing the data used on his recent submitted paper (ACP)

# Quantitative Evaluation Process

- Georgios Tsegas visited CPTEC/INPE in the week of 8-14 of February, 2015 as a STSM funded by COST ES 1004 – Action.
- The STSM involved a collaboration of the Laboratory of Heat Transfer and Environmental Engineering of the Aristotle University Thessaloniki with the Center for Weather Forecasting and Climate Research with the aim of establishing an analysis database and web platform for the assessment of model calculations, including the addition of new features supporting the comparison of model output with observations.
- A standard format for the WGNE data sets was defined (to conform with EuMetChem's)
- Scripts were developed to convert meteo station data to a format compatible with CPTEC's GrADS Online
- Work is being put into converting the WGNE sets into the standardized NetCDF format
- We're looking into OpenDAP/GDS to supply simulation data and as meta-information to the public
- Georgios will talk with the BSC and check if GrADS Online might be a viable solution for their web interface.

# Next Steps

- Perform data evaluation using
  - Atmospheric observational data from CPTEC/Brazil, CMA/China, ECMWF(?).
  - Retrieved/Analyzed/Observed AOD data from NASA/Goddard provided by A. Silva and from AERONET.
  - TRMM/meteo station rainfall data.

- Produce a report and a paper.

- Propose a second phase (?):
  - Revised runs and datasets (if needed).
  - Constrain initial and boundary conditions using a unified data/procedure by data assimilation.
  - Improves the diagnostic approach of indirect effect ( e.g. clear definition of the physical process(es) being represented, more detailed information about the representation of aerosols (e.g. speciation, extinction coefficients, etc. )

# Merge with similar initiatives (?)

- Merging with the initiative in Asia/G. Carmichael – MICS: Model Intercomparison Study—Asia – phase III.
  - Similar case (Beijing)
  - We will share information, tools for diagnostic, mainly for the indirect effect.
  - There will be a workshop at end of this year. WGNE is invited to participate.
- G. Carmichael suggested a meeting to integrate the initiatives GAW/WGNE and others to design a route for the future work/collaboration between them.

- We are open to new participants.

- Thanks for your attention!
- Questions ?

# Appendix 1

Centers participants and
a general description of their modeling systems

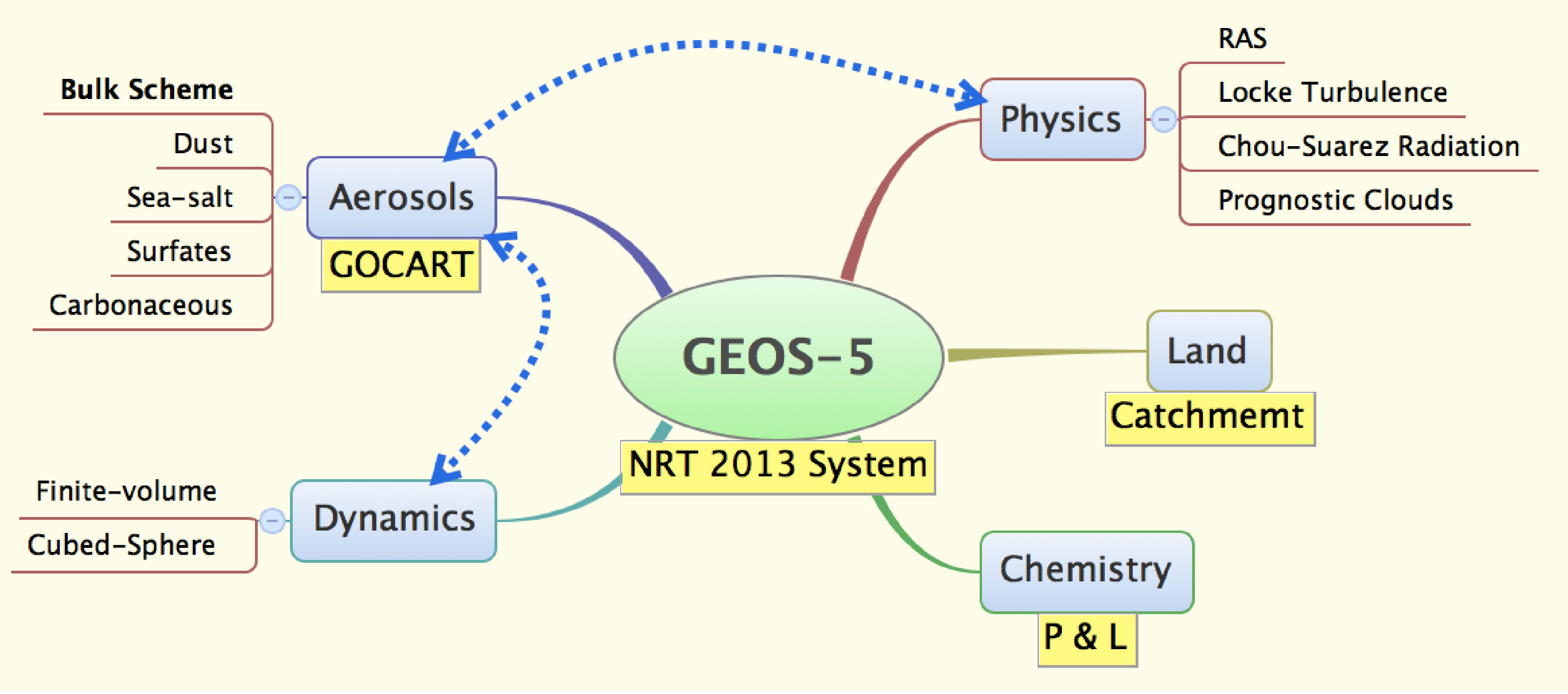
# Centers participants and a general description of their modeling systems: Global Scale

- NASA/Goddard
  - GEOS-5 with GOCART aerosol model.
  - GOCART bulk model for dust, sea-salt, sulfates, carbonaceous
  - Global, 25 km, 72 levels, top at 0.01hPa
- JMA
  - MASINGAR mk-2 aerosol model + MRI-AGCM3 (dynamics)
  - 2-moment bulk cloud model w/ explicit aerosol effects
  - Interactive components: sulfate, BC, organics, sea-salt and dust.
  - Prescribed emissions from MACCity and GFAS 1.0
  - Global TL319L40, top at 0.4 hPa
- NCEP
  - NOAA/NCEP Global Forecast System (GFS)
  - Radiation based on Rapid Radiative Transfer Models (RRTM)
  - A climatological aerosol distribution at 5° resolution (Hess et al., 1998)
  - Only consider direct radiative effect.
  - Global model T574L64, top at 0.32 hPa.

# Centers participants and
# a general description of their modeling systems:
# Limited Area Models

- Meteo-France and Met. Service of Algeria
  - ALADIN LAM coupled with Dust Entrainment and Deposition (DEAD) model.
  - Dust transport and optical properties are calculated using the three-moment Organic Inorganic Log-normal Aerosol Model (ORILAM) (Tulet et al. 2005)
  - Radiation RRTM for LW and FMR for SW.
  - Only direct effect.
  - Resolution 7.5 x 7.5 km and 70 levels
  - IC/BC from ARPEGE global model.
  - Case 1 only.
- CPTEC/Brazil
  - BRAMS LAM coupled with the CCATT aerosol-chemistry model.
  - Focus on biomass burning aerosol (Case 3)
  - Brazilian biomass burning emission model coupled with an interactive plumerise model
  - Direct effect using CARMA radiation parameterization
  - Indirect effect included at 2-moment bulk cloud scheme (under development)
  - Indirect effect included at cumulus convection scheme
  - Resolution: 10 x 10 km, 50 levels
  - IC/BC from GFS + MACC

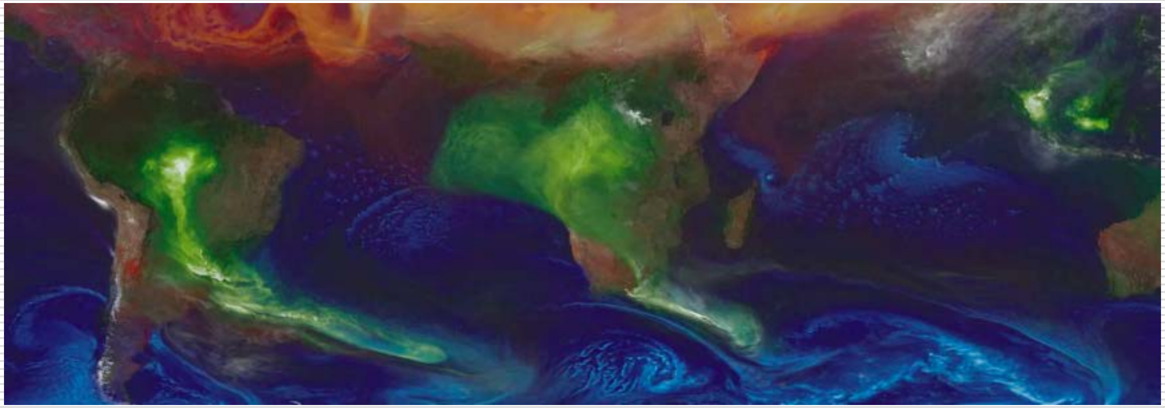
# 2013 NRT
# GEOS-5 Configuration




Global, 25 km, 72 Levels, top at 0.01 hPa

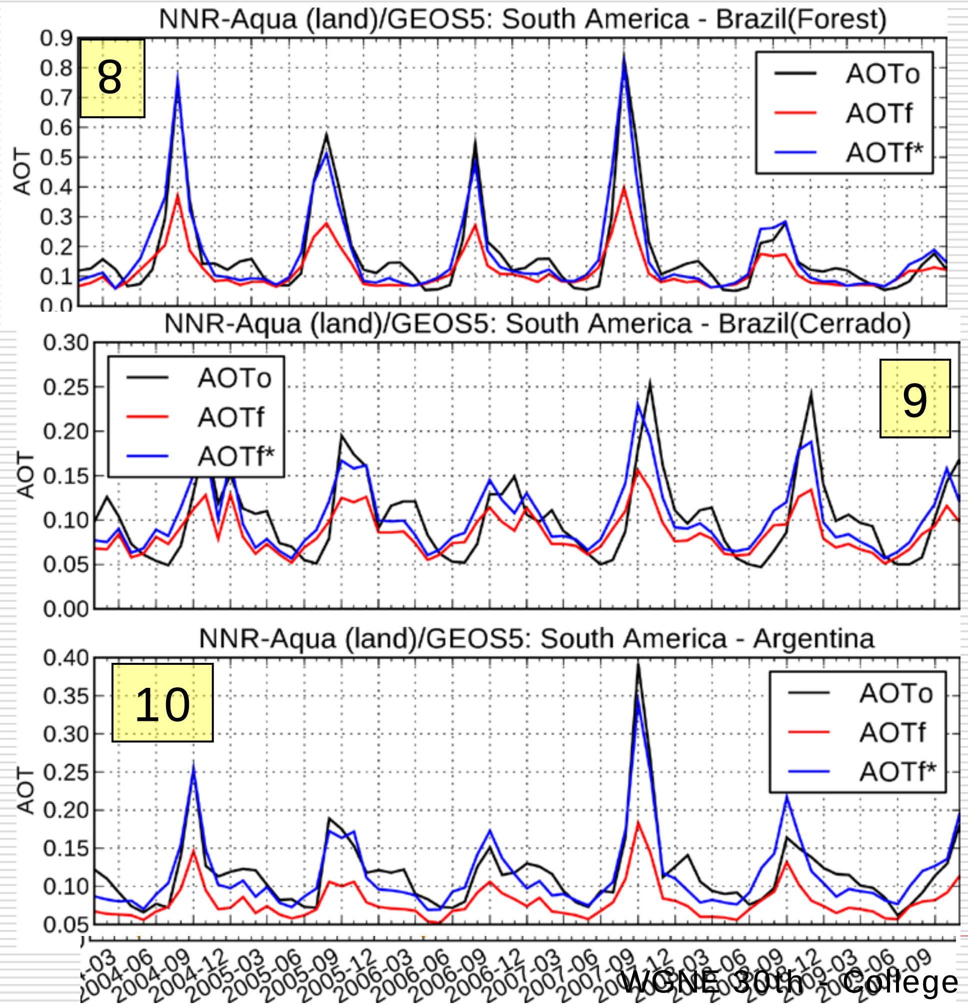
# QFED: Quick Fire Emission Dataset

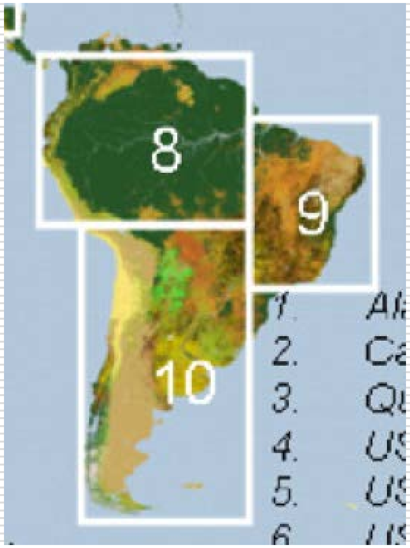
- Top-down algorithm based on MODIS Fire Radiative Power (AQUA/TERRA)
- FRP Emission factors tuned by means of inverse calculation based on MODIS AOD data.
- Daily mean emissions, NRT (thanks to LANCE)
- Prescribed diurnal cycle



JCSDA: inclusion of geo-stationary information

# QFED Calibrated by MODIS AOD




*GEOS-5 Aerosol Optical Depth*

__ QFED (GFED Calibrated)

__ QFED (MODIS Calibrated)

__ MODIS Retrievals

# NCEP's contributions to the WGNE aerosol-NWP experiment

- NOAA/NCEP Global Forecast System (GFS):
  - The cornerstone of NCEP's operational production suite, providing deterministic and probabilistic guidance out to 16 days over a global domain, four times daily at 00, 06, 12, and 18 UTC
  - Global spectral model with a comprehensive physics suite (http://www.emc.ncep.noaa.gov/GFS/doc.php)
- GFS Configuration (current operation → planned FY14 upgrade)
  - Eulerian dynamics → Semi-Lagrangian dynamics
  - T574 Eulerian (~ 27 km) out to 8 days; T190 Eulerian (~ 70 km) from 8 to 16 days → T1534 SLG (~ 13 km) out to 10 days; T574 SLG (~ 35 km) from 10 to 16 days
  - 64 vertical levels up to 0.32 mb
- GFS physics relevant to this WGNE experiment
  - Radiation parameterizations are based on Rapid Radiative Transfer Models (RRTMG_LW v2.3 and RRTMG_SW v2.3) with NCEP's modification and optimization
  - A climatological aerosol distribution at 5° resolution (Hess et al., 1998) is used.
  - Cloud microphysics is based on Zhao and Carr (1997)
  - Only consider direct radiative effect

# NCEP’s contributions to the WGNE aerosol-NWP experiment

- GFS experiment setup:
  - Use the latest GFS source code (targeted for the FY14 upgrade)
  - Same configuration as the operational GFS (e.g., T574 L64, Eulerian dynamics) except for output/zero-out frequency
  - Output every 3 hour, with the same 3-hourly interval for time averaging and accumulation
  - Initialized from 00Z analysis from Global Data Assimilation System (GDAS)
- Experiments conducted at NOAA R&D supercomputer (Zeus)
  - CTRL: with radiation feedback using climatological aerosols
  - EXPT: without radiation feedback
- Three cases are completed:
  - Dust: 10-day forecast for the 2012-04-13 to 2012-04-23 period
  - Pollution: 10-day forecast for the 2013-01-07 to 2013-01-21 period
  - Smoke: 5-day forecast for the 2012-09-05 to 2012-09-15 period
- GFS output (in GRIB1 format) are mapped from Gaussian grids to 1x1 deg
- The NCEP/EMC team contributing to this experiment: Sarah Lu (the NCEP POC), Yu-Tai Hou, Shrinivas Moorthi, and Fanglin Yang

# JMA/MRI: Model description

- Model: MRI/JMA Global model MRI-AGCM3 (dynamics) + MASINGAR mk-2 (aerosol)
  - Grid resolution: TL319L40 (horizontal: 640x320, Vertical $\eta$-coordinate from the ground to 0.4 hPa)
  - Dynamics framework: conservative semi-Lagrange method.
  - Tiedtke-like cloud convection scheme
  - 2-moment bulk cloud scheme that explicitly represents aerosol effects on liquid and ice clouds
  - Optical properties of aerosols: OPAC (Hess et al., 1998).
  - Hygroscopic growth factors: Chin et al. (2002).
  - Interactive aerosol components: sulfate, BC, OA, Sea salt and Dust

References


- Yukimoto et al., 2012, *J. Meteorol. Soc. Jpn.*, doi:10.2151/jmsj.2012-A02
- Yukimoto et al., 2011, *Technical Reports of the Meteorological Research Institute*, No.64, ISSN 0386-4049.

# JMA/MRI: Model configurations

- Anthropogenic emissions: MACCity emissions
- Biomass burning emissions: GFAS v1.0 (Kaiser *et al.*, 2012)
- Analysis:
  - Horizontal wind components are nudged toward the JMA global analysis fields.
  - SST: COBE-SST (Ishii *et al.*, 2005)

Submitted outputs are cropped to the region of the interest.

Case 1: 0 – 60 E, 0 – 50 N

Case 2: 86 – 146 E, 10 – 70 N

Case 3: 270 – 330 E, 20 – 40 S

# Meteo-France and Meteo-Service of Algeria

**ALADIN**: **A**ire **L**imitée, **A**daptation dynamique, **D**éveloppement **I**nter**N**ational (Limited Area, dynamical Adaptation, InterNational Development)

- ❑ Primitive equations model using a two-time-level semi-Lagrangian semi-implicit time integration scheme and a digital filter initialisation (Bubnová et al. 1995; Radnóti 1995)
- ❑ Lambert conformal projection with a bi-Fourier spectral representation and elliptical truncation.
- ❑ Coupled with ARPEGE global model every 3 hours

**Physics:**

- ❑ Prognostic TKE turbulence « CBR » (Cuxart, Bougeault, Redelsperger, 2000)
- ❑ Non local mixing length « BL89 » (Bougeault and Lacarrere, 1989)
- ❑ Mass flux shallow convection based on CAPE closure (Bechtold et al., 2001)
- ❑ Mass flux deep convection based on moisture convergence closure (Bougeault, 1985)
- ❑ RRTM (Rapid Radiative Transfer Model) scheme for long wave radiation (Mlawer et al. 1997)
- ❑ FMR (Fouquart-Morcrette Radiation) scheme for shortwave radiation with the 6 spectral bands (Fouquart et al. 1980, Morcrette 1991)
- ❑ Lopez microphysics with four prognostic hydrometeors (auto-conversion, collection, evaporation, sublimation, melting, freezing and sedimentation) (Lopez, 2002)
- ❑ Surface processes are calculated by the externalized surface scheme SURFEX (Masson et al., 2013) which includes the Interaction Soil Biosphere Atmosphere (ISBA) scheme (Noilhan and Planton 1989, Noilhan and Mahfouf 1996)

# Meteo-France and Meteo-Service of Algeria

## Dust emission and transport model

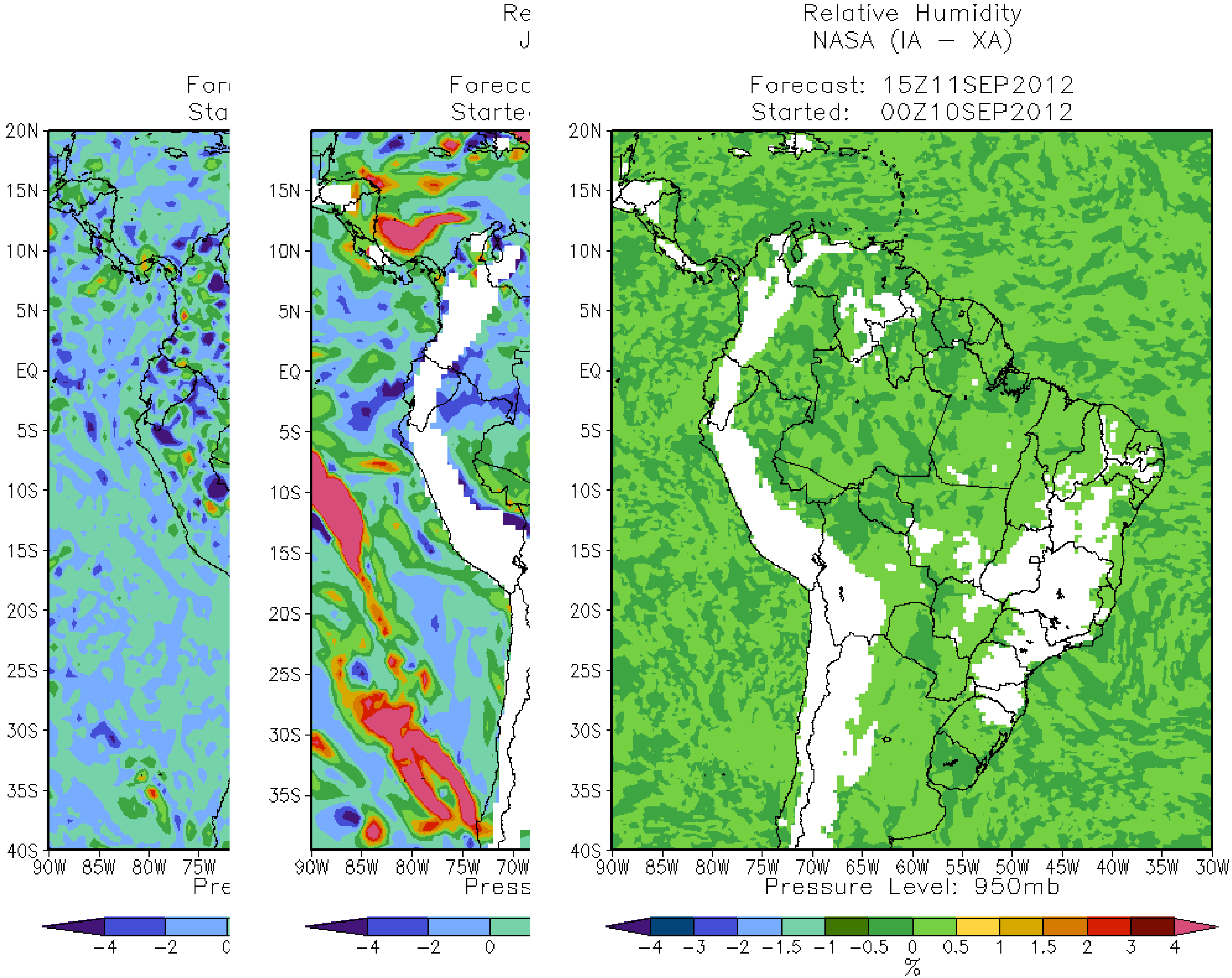
- ❑ Dust fluxes are calculated using the Dust Entrainment And Deposition (DEAD) model (Zender et al. 2003a) coupled to SURFEX scheme by Grini et al. (2006) and recently improved by Mokhtari et al. (2012).
- ❑ Saltation flux is calculated following the Marticorena and Bergametti (1995) scheme
- ❑ Vertical flux is done using the Shao (1996) relationship
- ❑ Erodible soil fraction is represented by the covers COVER004 and COVER005 derived from the global 1 km ECOCLIMAP database relating to bare and rock soil, respectively (Masson et al. 2003)
- ❑ Mass fractions of clay, sand and silt are provided from the global 10 km FAO soil database (Masson et al. 2003)
- ❑ Soil texture is classified following the USDA (1999) (United States Department of Agriculture) textural classification with 12 basic textural definitions
- ❑ Dust transport and optical properties are calculated using the three-moment Organic Inorganic Log-normal Aerosol Model (ORILAM) (Tulet et al. 2005)

### Model configuration

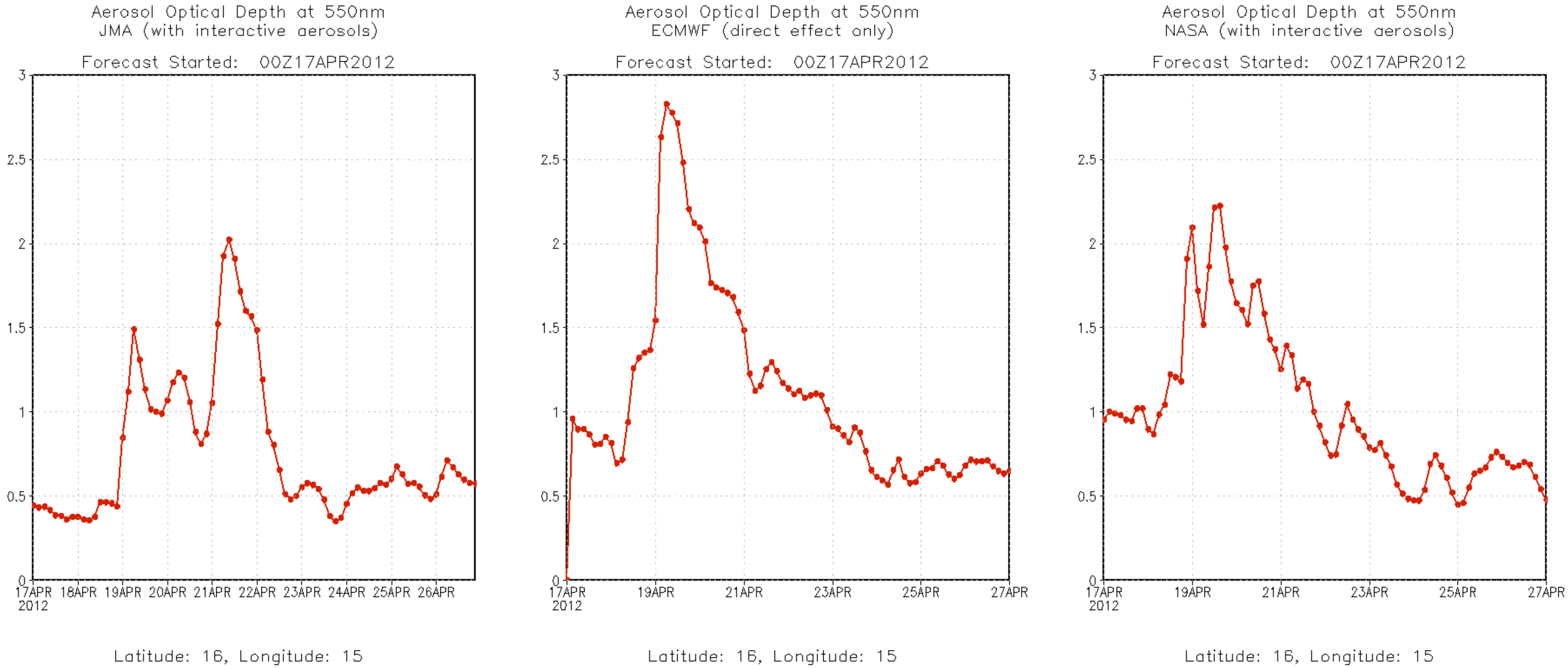
- ❑ Horizontal resolution: 7.5 x 7.5 km
- ❑ Vertical resolution: 70 levels
- ❑ Number of points: 400 x 400
- ❑ Georeference information for post processing:

- Number of points is 340x340
- Resolution lat/lon (deg): 0.07° x 0.07°
- Latmin=13.135, Latmax=36.86, Lonmin=18.135, Lonmax= 41.86
- Centre of domaine: (lat, lon) = (25° N,30° E)

# Backup slides



Relative Humidity
NASA (IA – XA)
Forecast: 15Z11SEP2012
Started: 00Z10SEP2012
20N
15N
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
90W
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
Pressure Level: 950mb
−4
−3
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
3
4
%



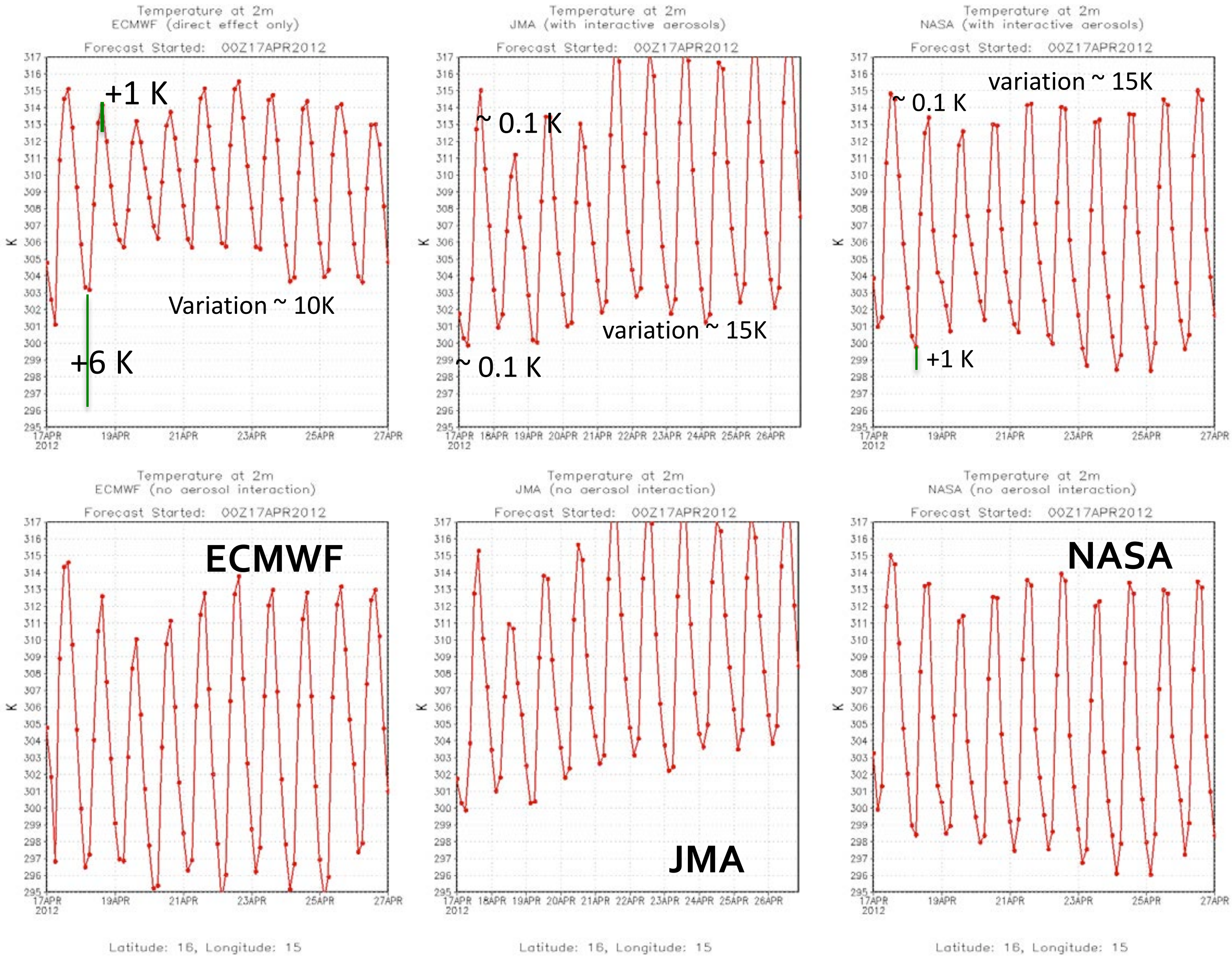
Aerosol Optical Depth at 550nm
JMA (with interactive aerosols)
Forecast Started: 00Z17APR2012
17APR 2012 18APR 19APR 20APR 21APR 22APR 23APR 24APR 25APR 26APR
Latitude: 16, Longitude: 15
Aerosol Optical Depth at 550nm
ECMWF (direct effect only)
Forecast Started: 00Z17APR2012
17APR 2012 19APR 21APR 23APR 25APR 27APR
Latitude: 16, Longitude: 15
Aerosol Optical Depth at 550nm
NASA (with interactive aerosols)
Forecast Started: 00Z17APR2012
17APR 2012 19APR 21APR 23APR 25APR 27APR
Latitude: 16, Longitude: 15

# 2m-Temp

## 10 days forecast (start:00UTC17APR2012)

AER

NO AER



# Grell-Freitas Convective Param

- **Scale-aware/Aerosol-aware (Grell and Freitas, 2014, ACP)**
  - Stochastic approach adapted from the Grell-Devenyi scheme (Grell and Devenyi, 2002, GRL; but many of the more computationally expensive ensembles have been cut for efficiency)
  - Scale awareness through Arakawa approach (2011) or spreading of subsidence
  - transitions to precipitating shallow-cumulus scheme as grid spacing decreases (can even use it at dx=1km!)
    - ➢ First temperature & moisture tendencies decrease as resolution increases
    - ➢ At very high resolution (dx < 3km) parameterized convection becomes much shallower – cloud tops near 800 mb (down from 200-300 mb).
    - ➢ Tendencies in general become very small, practically shutting off below 5 km grid spacing.

# Aerosol awareness

**Constant autoconversion rate id changed to aerosol (CCN) dependent Berry conversion**

**Evaporation of raindrops is changed (Jiang and Feingold) based on empirical relationship**

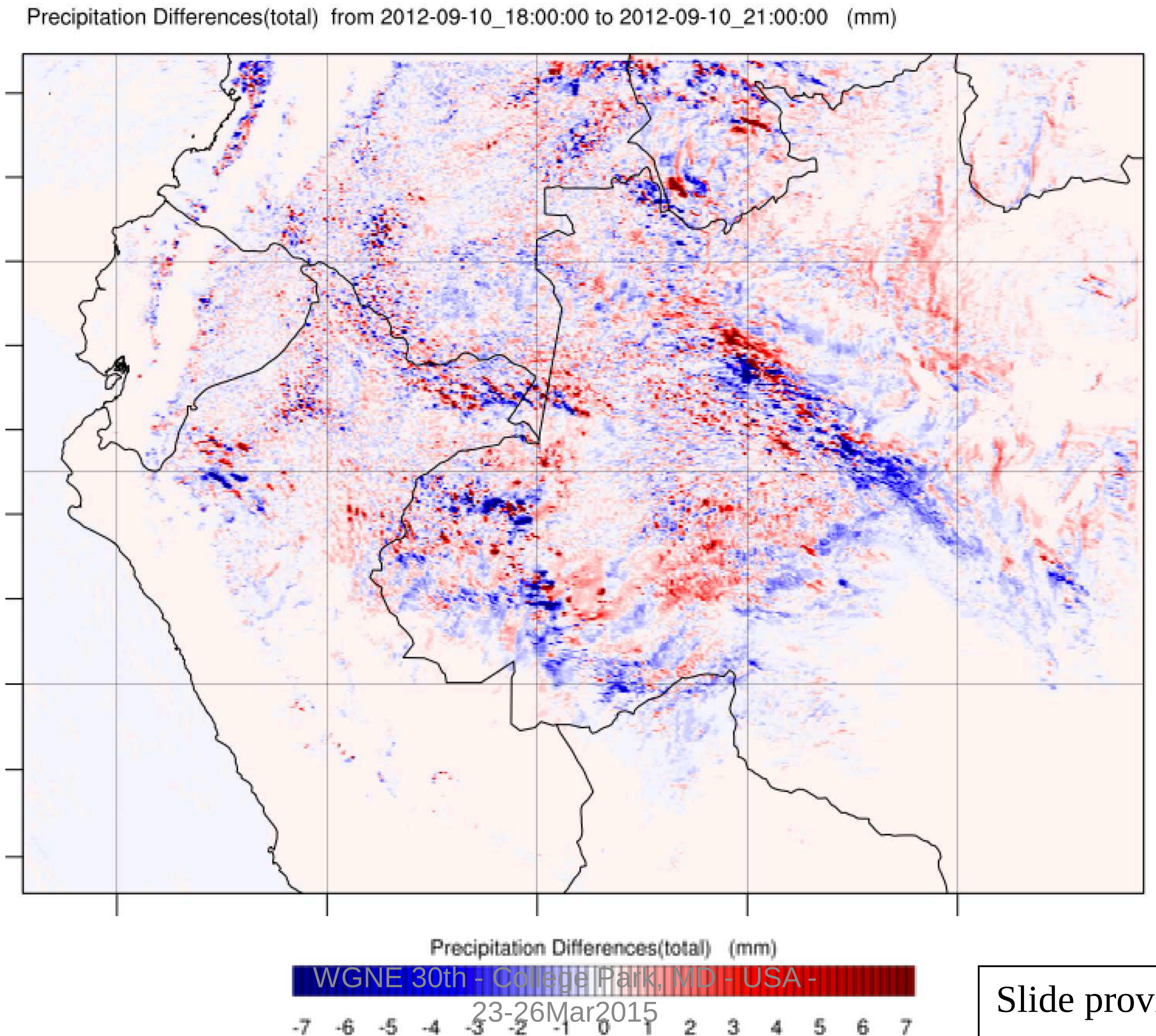
$$\left(\frac{\partial r_{rain}}{\partial t}\right)_{\substack{\text{autoconversion}\\ \text{Berry, 1968}}} = \frac{(\rho r_c)^2}{60\left(5 + \frac{0.0366\ CCN}{\rho r_c m}\right)}$$

$$PE \sim (l_1)^{\alpha_s - 1}(CCN)^{\zeta} = C_{pr}(l_1)^{\alpha_s - 1}(CCN)^{\zeta}$$

**CCN can be from complex model results (WRF-Chem), or simply from observed AOD (global or regional analysis)**

Evaporation effect will have a strong impact on downdrafts, but is limited by other environmental conditions (e.g., If the precipitation efficiency is already very low, it cannot get much lower, and vice versa)

# 3-hourly precipitation differences at Sep 10, 21Z (MET-CHEM)






Slide provided by G. Grell