Aerosol Interactions with Physics

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Evaluating the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) Schemes on Rainfall Forecast in the NGGPS

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1. Use a variety of observation data to continue identify and quantify the impact of aerosol on cloud and precipitation.

2. Evaluate the performance of the GFS baseline model in simulating clouds and precipitation before any new scheme is introduced as benchmarks.

3. Investigate any dependence of model biases in simulating clouds and precipitation on aerosol properties under different meteorological conditions.

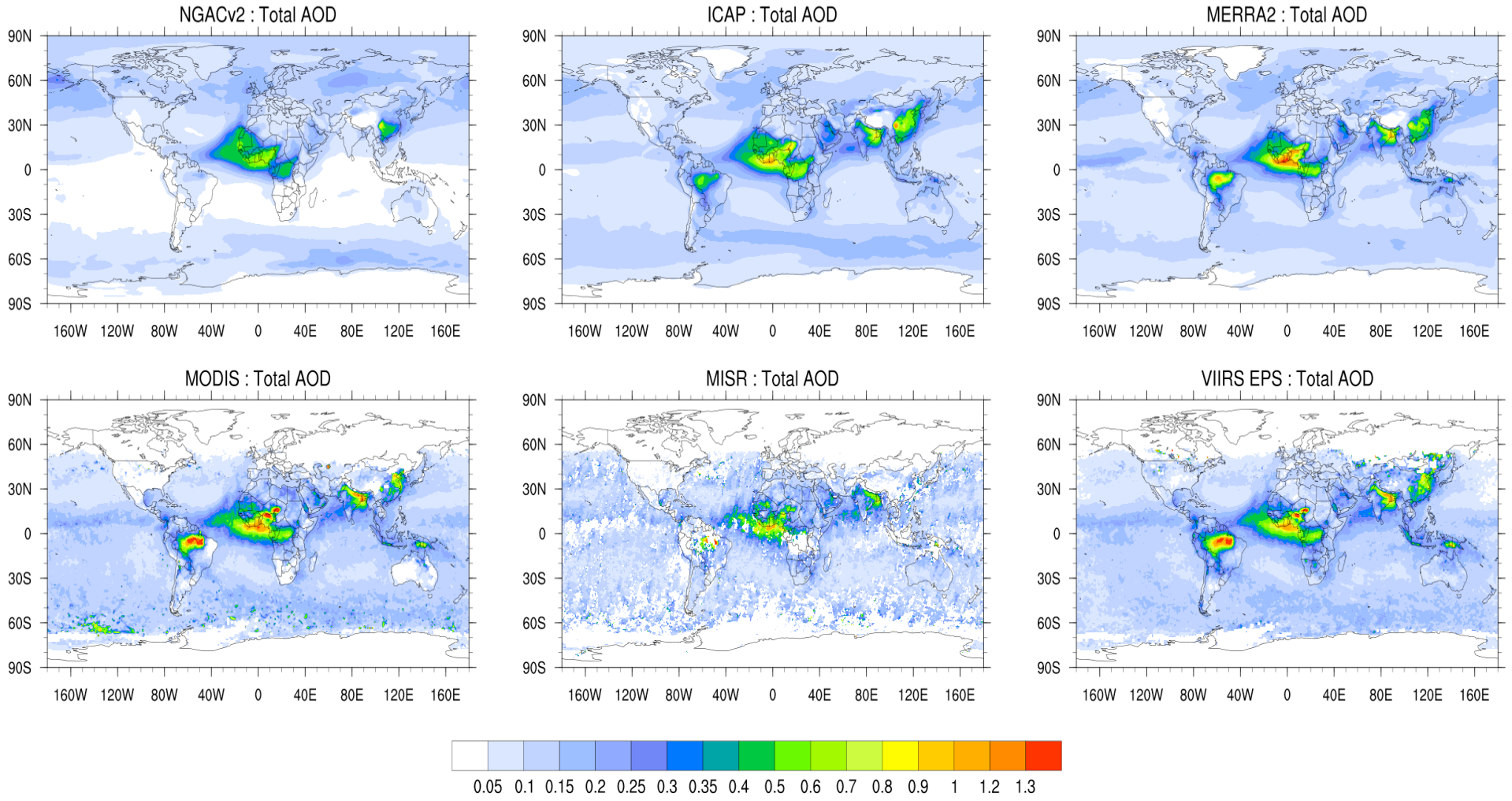
4. Select certain cloud systems, run the CRM with NGGPS-selected parameterization schemes, and compare the CRM against GFS/ NGGPS results .

Status of NGAC

- NGAC-v2 and ICAP operational (PI Sarah Lu)
  - Near-real-time operational system
  - AGCM : NCEP's NEMS GFS
  - Aerosol: GSFC's GOCART
  - 120-hr dust-only forecast once per day (00Z), output every 3-hr
  - ICs: Aerosols from previous day forecast and meteorology from operational GDAS
  - Implemented into NCEP Production Suite in Sept 2012
  - Some evaluation of AOD with MODIS, VIIRS, MERRA satellite data and AERONET sunphotometers

ICAP = International Cooperation for Aerosol Prediction

Monthly mean AOD (550nm) : December, 2015



http://www.emc.ncep.noaa.gov/gmb/NGAC/NGACv2/Monthly/Total/Global/Glb_Dec_2015.png

Sources of aerosol

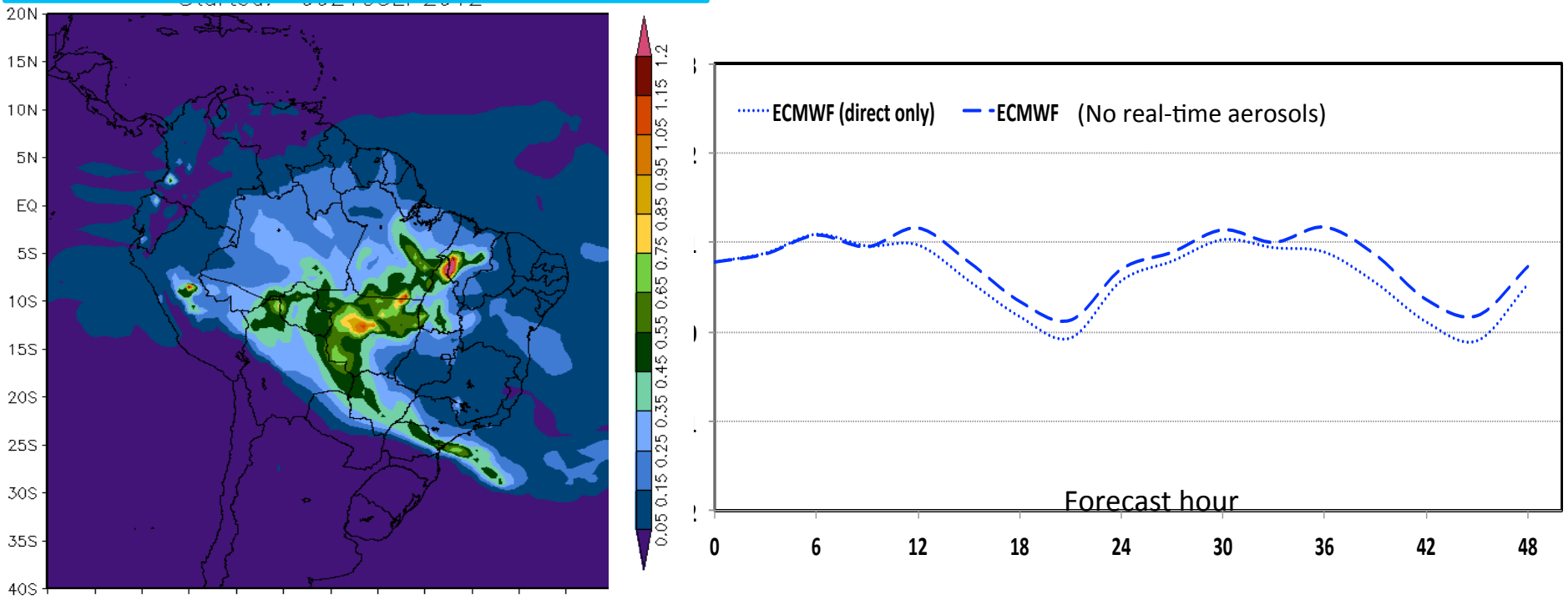
Aerosol life cycle and processes

Working Group for Numerical Experimentation (WGNE) exercise: Impacts of aerosols on weather prediction

Case 3- Persistent Smoke in Brazil - SEP 2012

AOD at 550 nm
27 hr forecast for 15UTC 11SEP

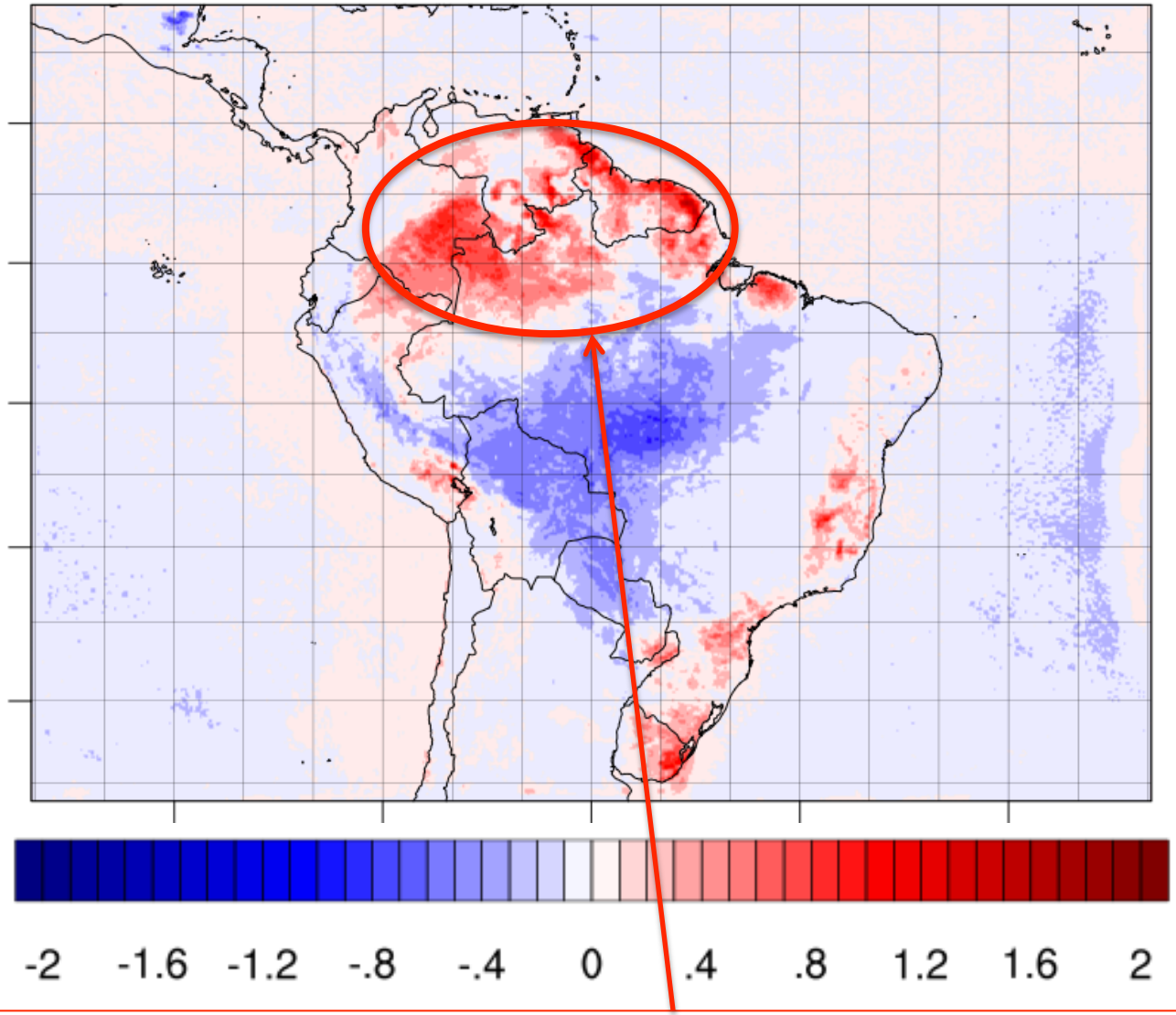
T2M BIAS, ECMWF



Largest impacts that are strongly real-time dependent should be always from biomass burning, dust, sea salt

Using a double moment microphysics scheme with and without real-time aerosol information: Average over 20 runs, 3 days, 12Z T2m differences,

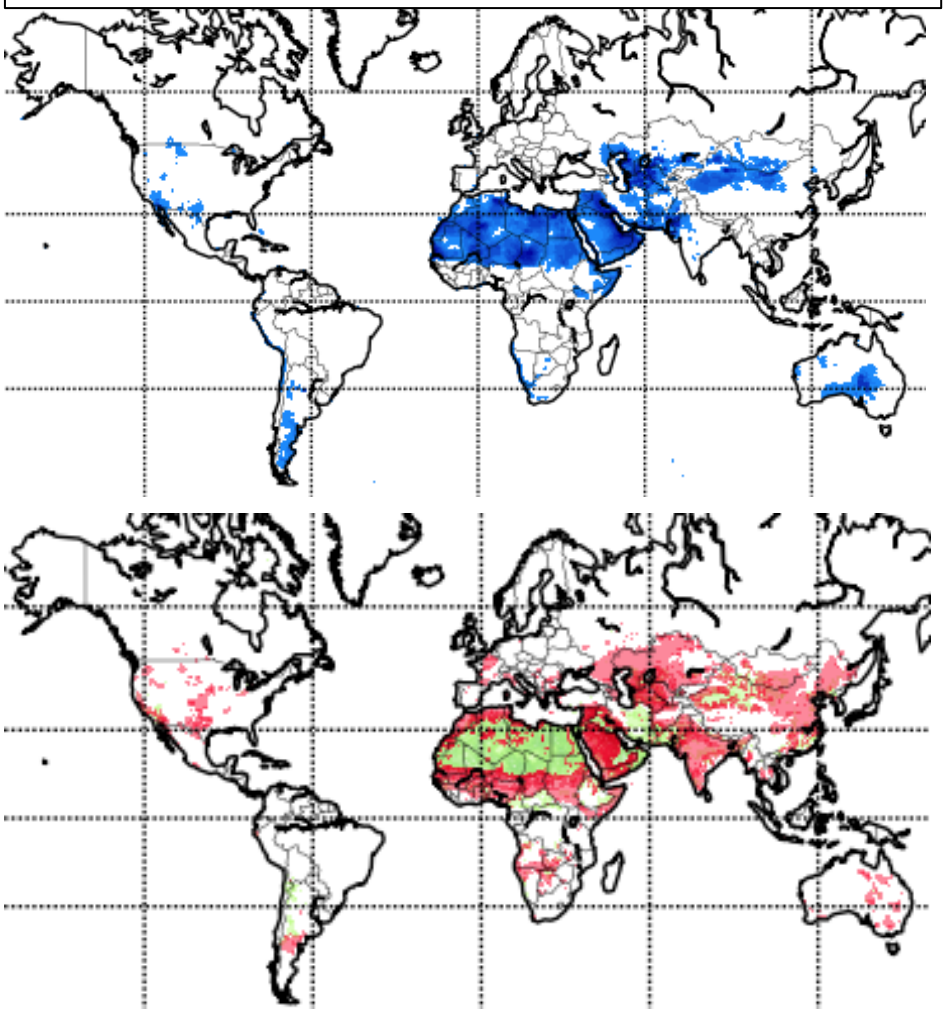
AER - NOAER



Low AOD: Most of this warming caused by not needing constant droplet number assumption in run without real-time aerosol information

Comparison of sources: Dust

Fraction of dust sources per grid cell



Old Sources (Ginoux et al. 2001)
Based on topography = **natural**

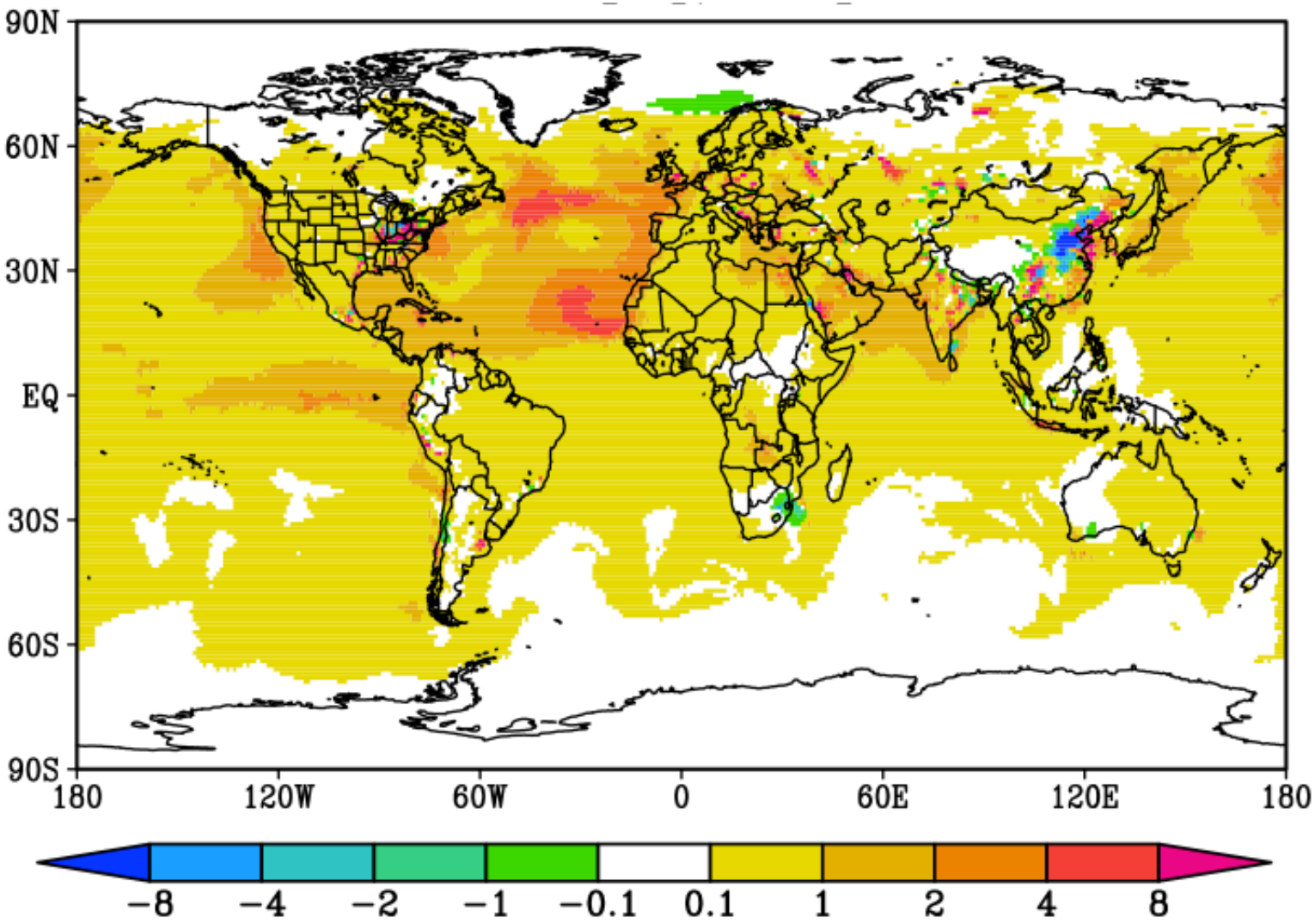
New Sources (Ginoux et al. 2012)
Based on dust optical depth
frequency of occurrence
with **anthropogenic** and **natural**

Anthropogenic dust sources = at least 10% of cropland or pasture within grid cell

Discussion points on aerosols and physics interactions

Can we predict aerosols with enough accuracy to warrant looking at impact on NWP? Will we be able to properly treat the interaction with physics?

- Are the chemistry/aerosol modules good enough? Do they have enough complexity?
- Is the data assimilation ready to take on aerosols with enough accuracy to provide a "good" initial analysis of required aerosol fields?
- Is the coupling to physics done with enough accuracy
  - Radiation
  - Microphysics
- Evaluations?
- Seasonal - versus sub seasonal - versus medium range - versus short range
  - For longer than medium range: what to do with biomass burning
  - For short range ? Fires, dust, data assimilation…? Would initial fields or climatologies be enough?
- Resolution



Difference of sulfate aerosols, resulting from 2 different 14 days retro simulations. One using GOCART simple chemistry (L0) and another sophisticated chemistry package (L1). Displayed is L1 – L0. **Differences are caused from much more complex treatment of aerosol chemistry** in L1. L0 is using climatological background values for OH, H_2O_2, and NO_3 while for L1 they are calculated at every timestep. Units are ug/ m^3.

Options for including aerosol impacts

- Online aerosol/chemistry on coarser resolution (ECMWF currently to go to 40km dx)
  - Advantage: possibly best representation of aerosols
  - Disadvantage: cost/possible complexity
  - Can provide climatologies, or real-time coarser resolution input, can also serve for input to AQ prediction system
- Aerosol aware physics already use simple aerosol arrays (water friendly, ice friendly as one example, RAP, HRRR) – together with initial analysis, fires, dust, and sea salt, is that enough?
- Just use "good" analysis of aerosols?
  - Cheap, but is it enough? Is it future (worth of NGGPS)?

Metrics for evaluation

No need to look at NWP impact, if aerosols are predicted with not enough accuracy, so rigorous evaluation is important

- Compare emission inventories: biomass burning, dust
- Scalar metrics for aerosol:
  - Budget: emission, deposition, lifetime compare to AEROCOM values
  - Surface concentration: IMPROVE over US, EMEP over EU, U of Miami, LISA in Sahel, PM10 by local EPA
  - Optical properties: Aerosol Optical Depth (AOD), Singles Scattering Albedo (SSA), and Asymmetry parameters (ASYM): data from NOAA ESRL, NASA AERONET, satellite (MODIS, MISR, VIIRS, etc.)
  - Vertical profile of extinction and aerosol mask: MPLNET, CALIOP

- Case studies of continental scale aerosol event with appropriate coverage of satellite and ground-based data (e.g. field campaign):
  - 1 within CONUS (e.g. Oct 18 , 2012)
  - 1 transatlantic (e.g. April 2012)
  - 1 transpacific (e.g. 2001 during ACE-Asia)

- Test Pattern correlation with satellite data
- Test Frequency of Occurrence of Aerosol events with satellite data

Best way forward with a focus on truly state-of-the-art yet affordable

Operational centers cannot switch options on a regular basis

– so which options to chose?

- Can we just get a team of “smart” people together to decide on the best way forward?
- Team should include data assimilation folks, chemistry/aerosol folks, maybe microphysics/radiation folks? **Might be worth a try..**