AEROSOL IMPACTS FOR CONVECTIVE PARAMETERIZATIONS:

APPLICATIONS OF THE GRELL-FREITAS CONVECTIVE PARAMETERIZATION

HANNAH C BARNES[1,2], GEORG GRELL[2], SAULO FREITAS[3]

[1]COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES AT THE UNIVERSITY OF COLORADO BOULDER, [2]NOAA GLOBAL SYSTEMS LABORATORY, [3]INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS - INPE - BRASIL

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THE GRELL-FREITAS (GF) CONVECTION PARAMETERIZATION

General Features

- Stochastic, scale and aerosol – aware
- Scale-awareness based on Arakawa (2011) approach
- GPU version available with bit for bit results
- Mass-flux based scheme
- Includes updrafts and downdrafts
- Represents deep, congestus, and shallow convection
- Originally published in Grell and Freitas 2014 (ACP)
  - Subsequent updates in Freitas et al. (2018, JAMES) and Freitas et al. (2021, GMD)

Details of Aerosol – Awareness

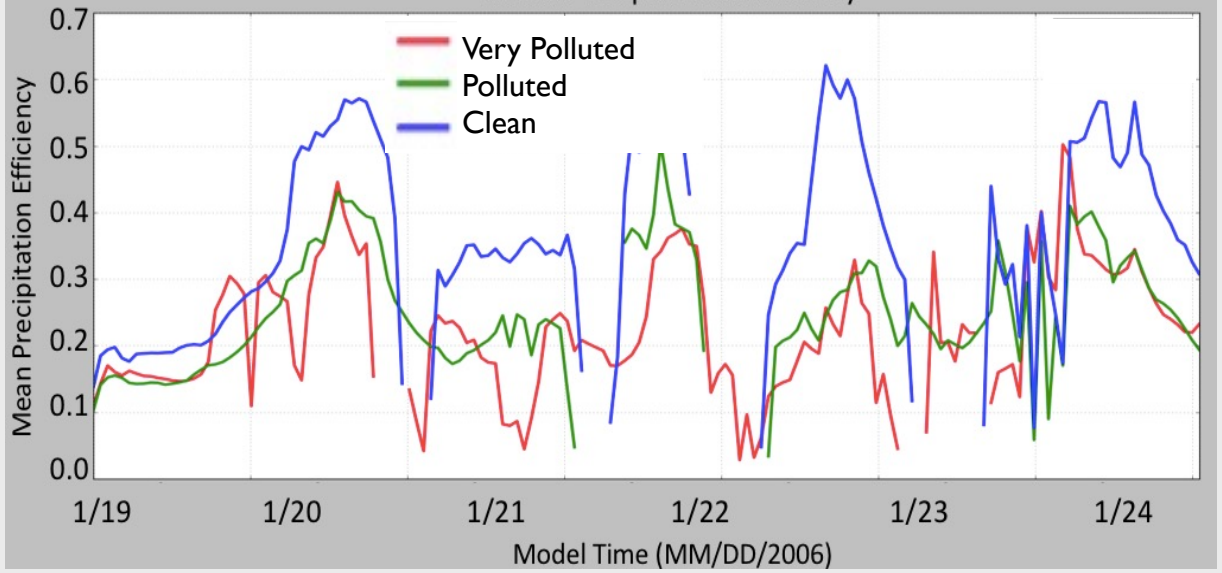
- Objective: Cost effective method to describe basic effects of aerosols
- Aerosol optical depth (AOD) defines a proxy for pollution / aerosols *(Rosenfeld et al. (2008), Andreae et al. (2008))*
  - Initial conditions based on MERRA2 climatology
- Processes influenced by aerosols
  - Auto-conversion - cloud water to rain *(Berry 1968)*
  - Evaporation of rain *(Jiang et al. 2010)*
  - Aerosol wet scavenging *(Lee and Feingold 2010, Wang 2013)*
- Aerosol impact based on how far the AOD at a given point is from an assumed background AOD
  - Makes aerosol impacts most notable in very clean or very polluted environments
- Active in congestus and deep convection

GF AEROSOL – AWARENESS

CONSISTENT RESPONSE ACROSS MODEL TYPES

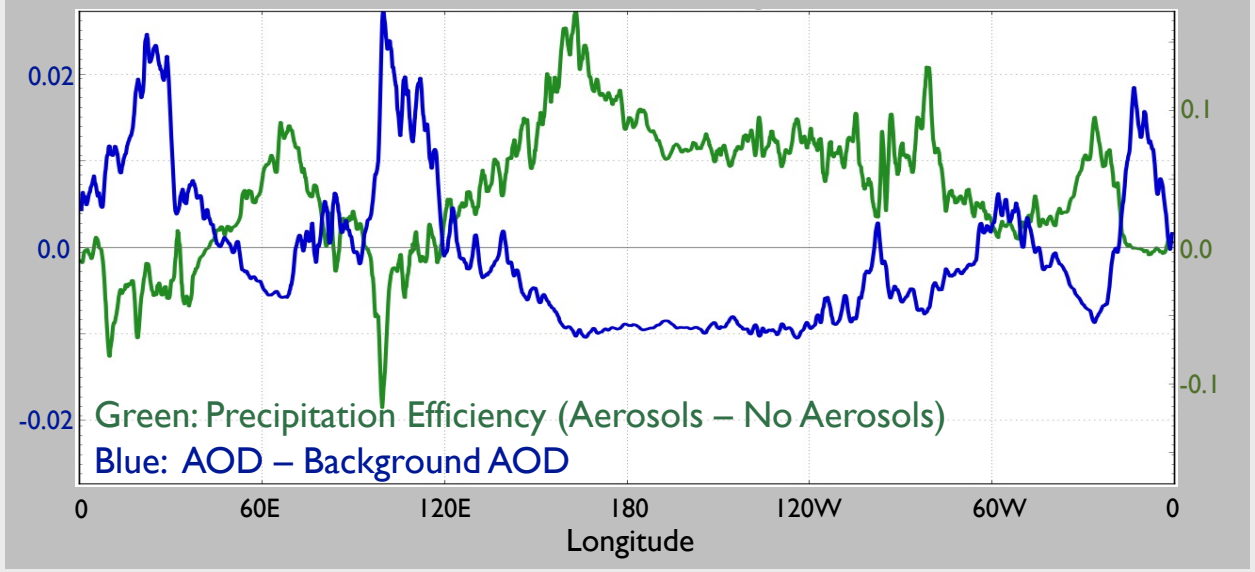
Single-Column Model Simulation of TWP-ICE

Time Series of GF Precipitation Efficiency



Full FV3 Simulation (120 hr forecast)

Meridional Average of GF Precipitation Efficiency vs Aerosol Optical Depth



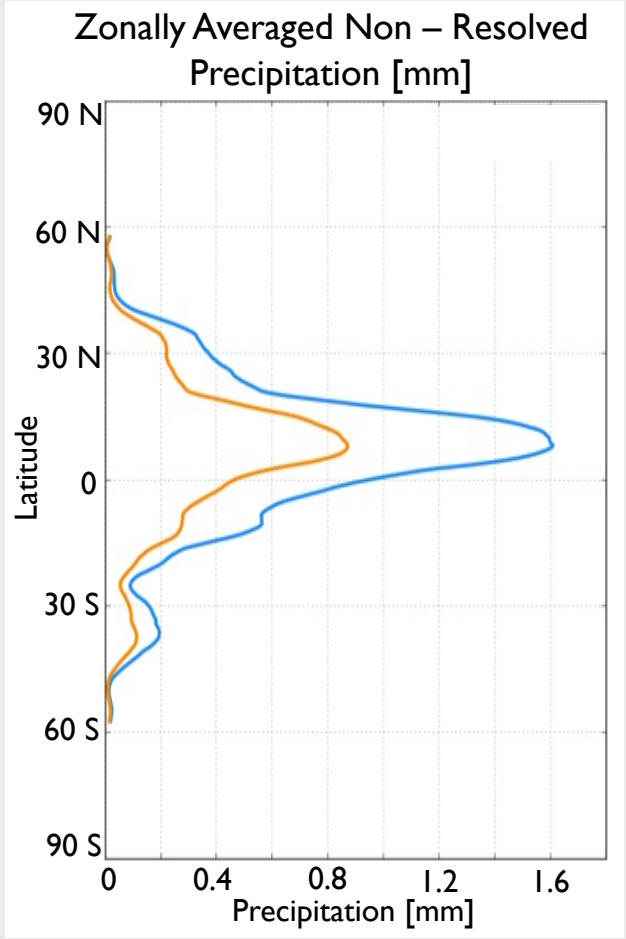
In both the single-column model and the full FV3 model precipitation efficiency is reduced when pollution is high.

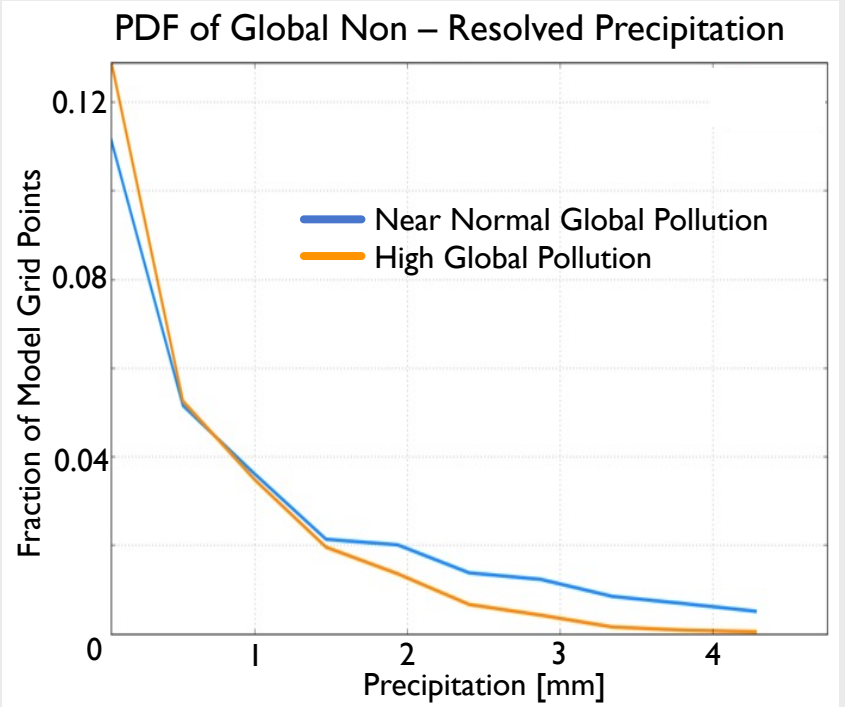
GF AEROSOL – AWARENESS

IMPACT ON GLOBAL MODEL FORECASTS

- Two global FV3 simulations for 120 hrs:
  - Near normal global pollution (blue line)
  - Heavily polluted world wide (orange line)

- **GF captures the accumulation and size distribution changes associated with heavy pollution**
  - Less non-resolved precipitation, more resolved precipitation
  - The non-resolved precipitation is less intense

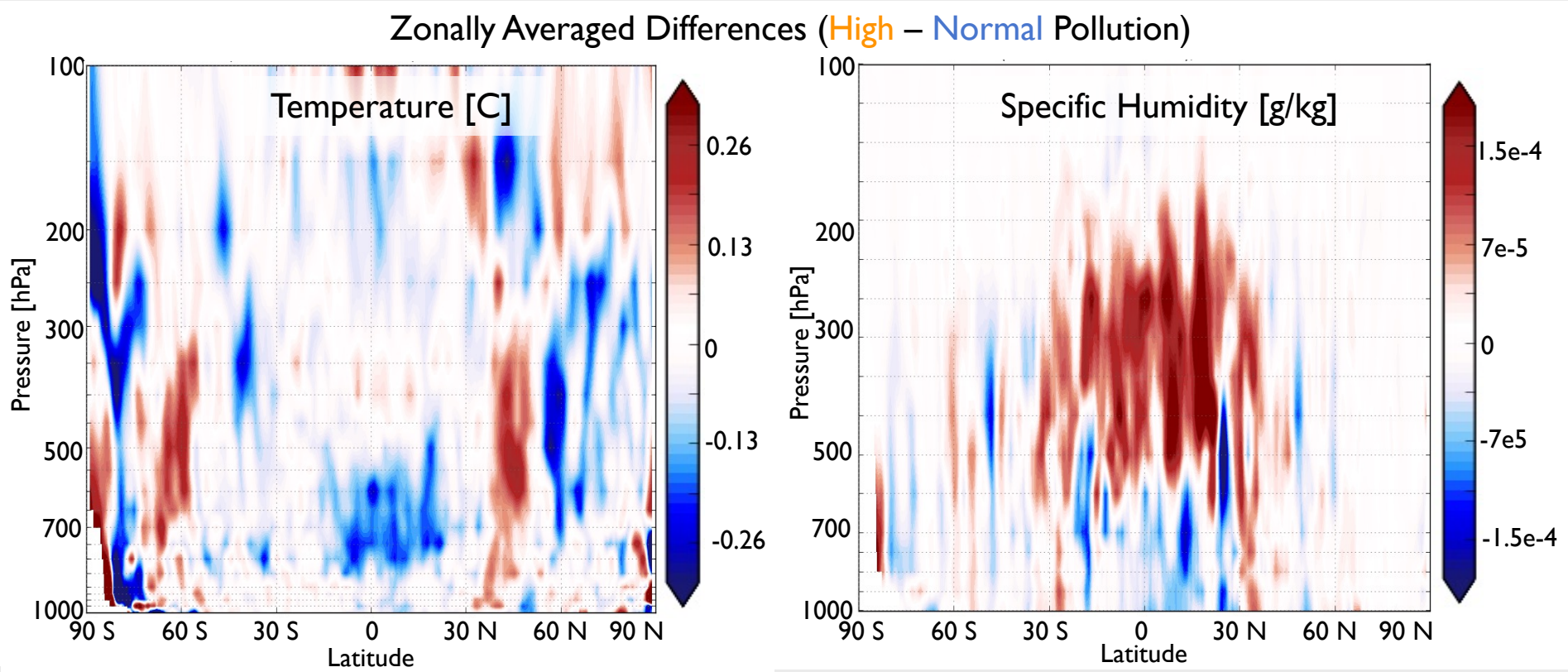




GF AEROSOL – AWARENESS

IMPACT ON MODEL FORECASTS

- When the temperature and specific humidity fields are compared:
  - Lower – levels are cooler and drier ⟶ suggesting stronger downdrafts
  - Upper – levels are more moist ⟶ suggesting more convective detrainment



Future work:

- **Tuning**
- **Include aerosol impacts on shallow clouds**
- **Compare results with WRF-Chem high resolution cloud resolving simulations over the Amazon region**