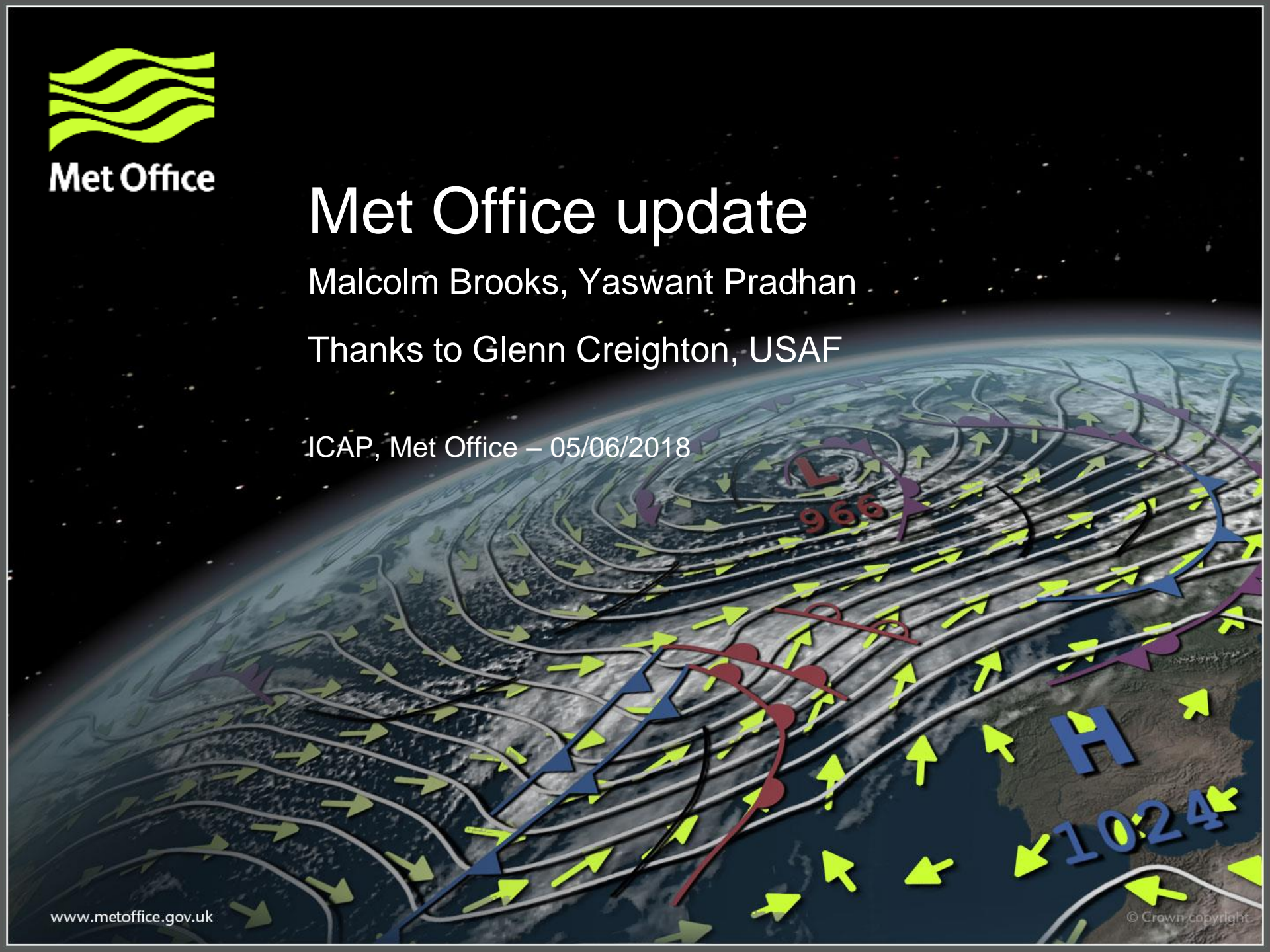# Met Office update

Malcolm Brooks, Yaswant Pradhan

Thanks to Glenn Creighton, USAF

ICAP, Met Office – 05/06/2018

Contents

# Global Model Forecasts

- Dust included in global model in 2011.

- Now at N1280 (~10km) resolution, 70 levels.

- 4D VAR ensemble-hybrid data assimilation of wind, temperature, humidity etc.

- 4D Var assimilation of MODIS dust obs. over land and sea.

- Soil Moisture assimilation uses ASCAT/Synop obs

- Dust advected with 2 bins

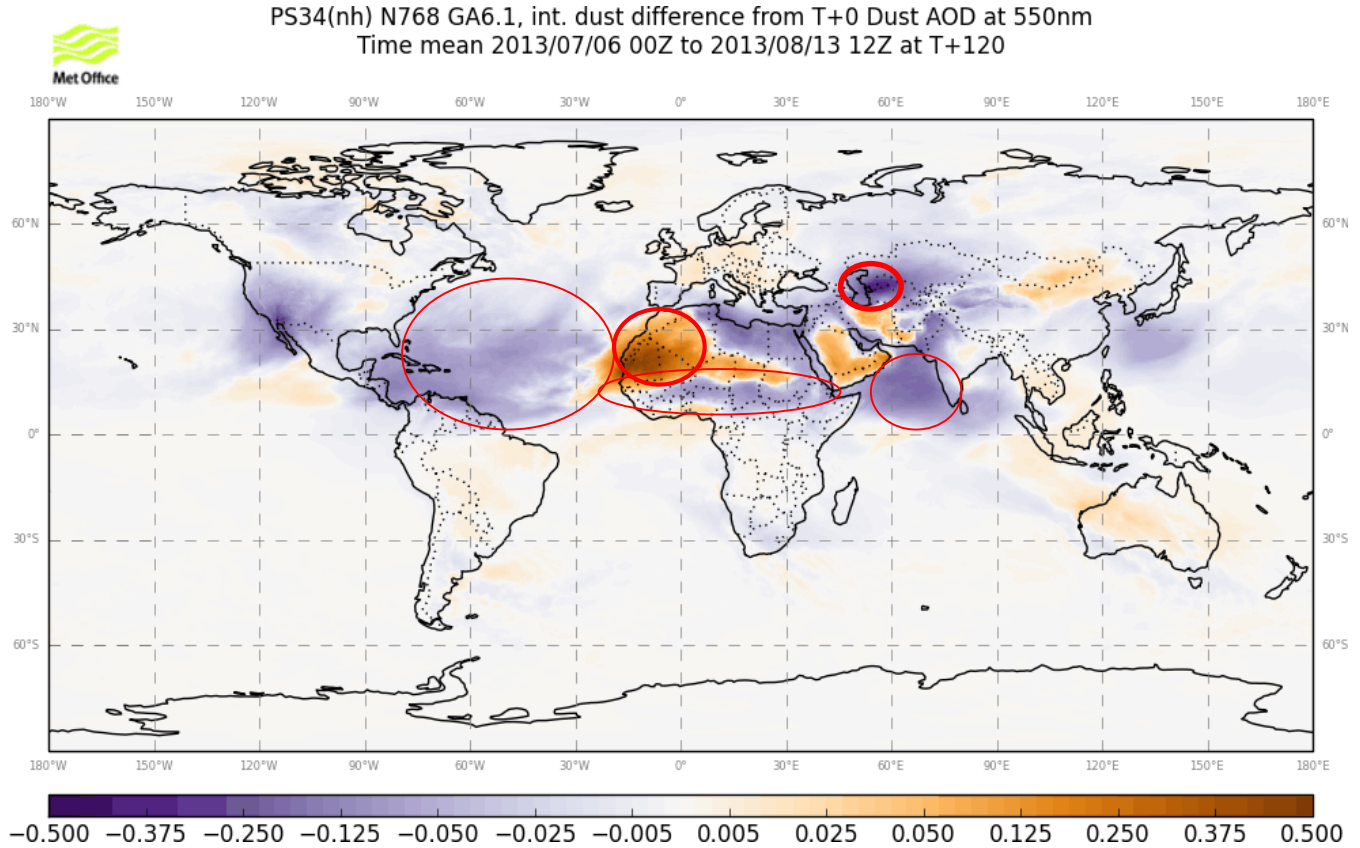- 2 main runs daily at 00Z and 12Z, runs for 144 hours

Met Office Oper. Global: Dust AOD at 550.0 nm
Sun 2017/10/15 12Z T+0 from 2017/10/15 12Z

MIN=0.000, MAX=1.461, MEAN=0.045, SD=0.103, RMS=0.112

Aerosol Optical Depth
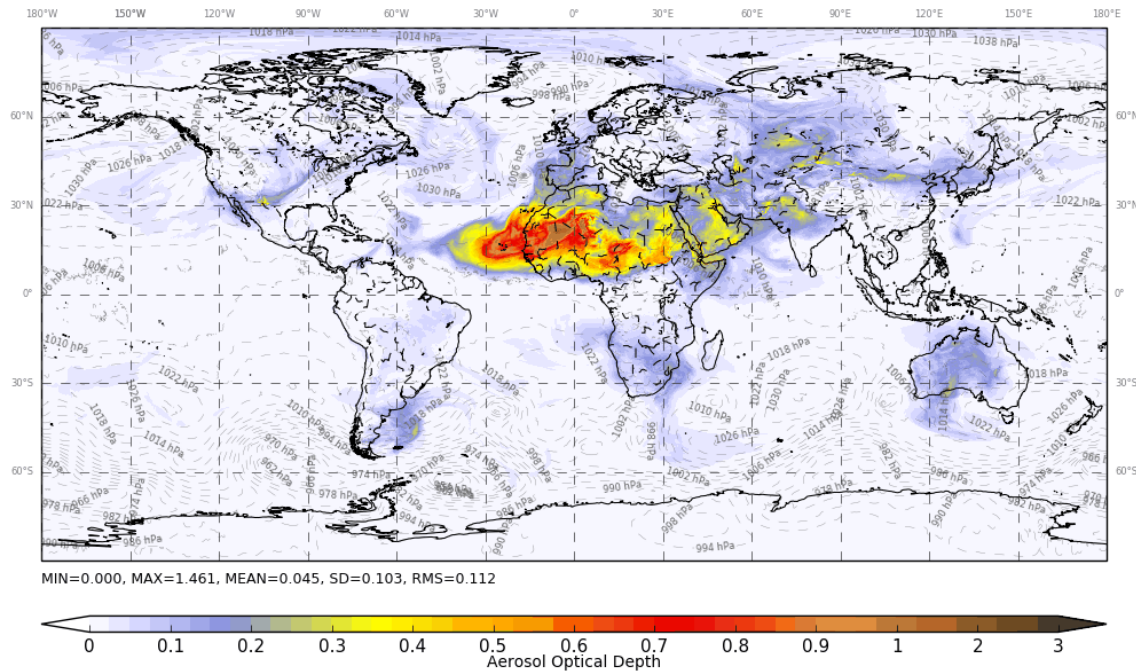
Current Dust model biases

From 2015 presentation:

PS34(nh) N768 GA6.1, int. dust difference from T+0 Dust AOD at 550nm
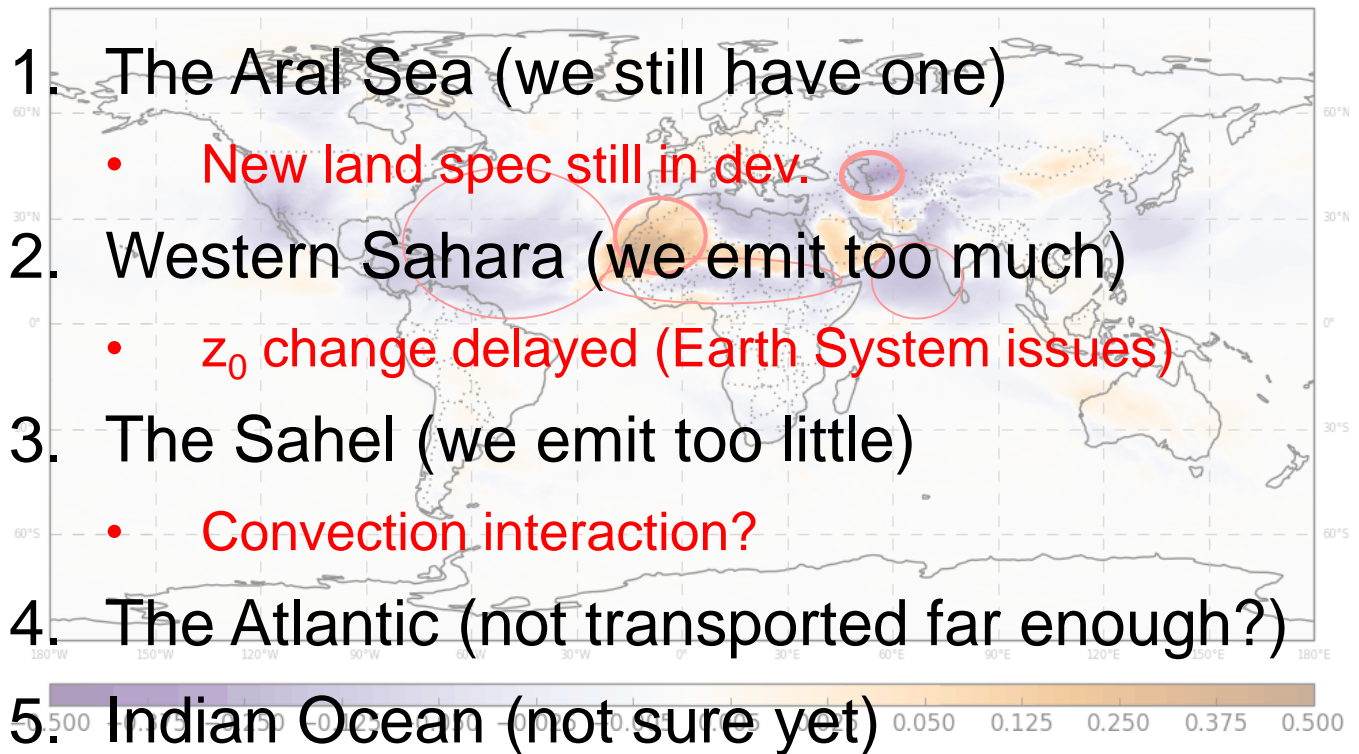Time mean 2013/07/06 00Z to 2013/08/13 12Z at T+120

Current model biases

Oceanic MYDAOD assimilation gives a better view of model biases.

Biases:

PS34(nh) N768 GA6.1, int. dust difference from T+0 Dust AOD at 550nm
Time mean 2013/07/06 00Z to 2013/08/13 12Z at T+120

1. The Aral Sea (we still have one)
   - New land spec still in dev.
2. Western Sahara (we emit too much)
   - z_0 change delayed (Earth System issues)
3. The Sahel (we emit too little)
   - Convection interaction?
4. The Atlantic (not transported far enough?)
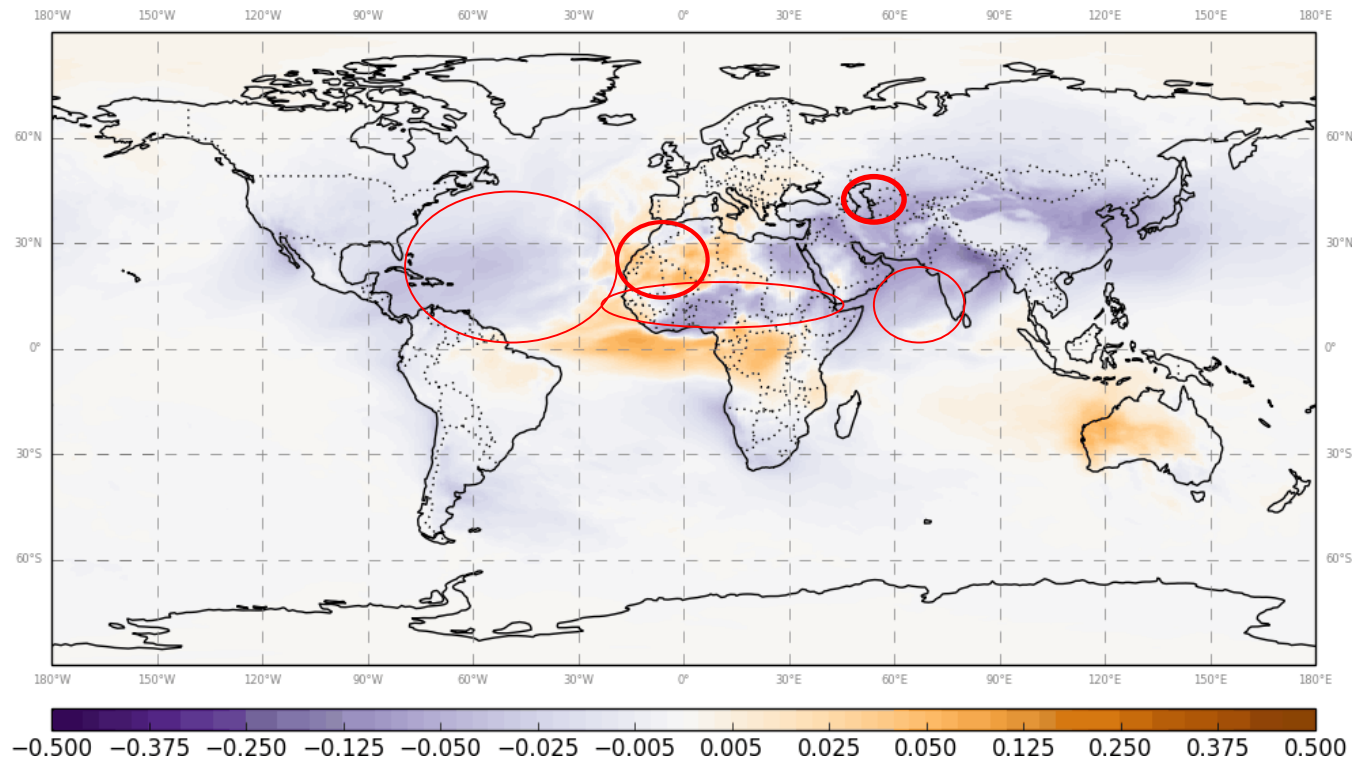5. Indian Ocean (not sure yet)

Current Dust model biases
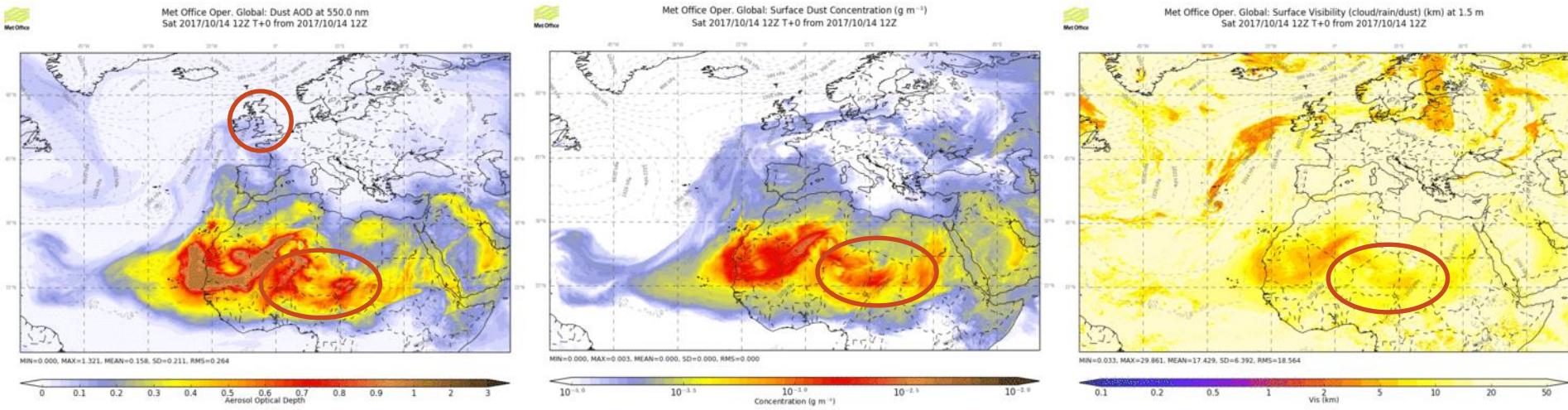
From a current trial period:

N320 PS39, us_am=2.20, horiz_d=0.7 difference from T+0 Dust AOD at 550nm
Time mean 2016/11/20 12Z to 2017/02/25 12Z at T+120
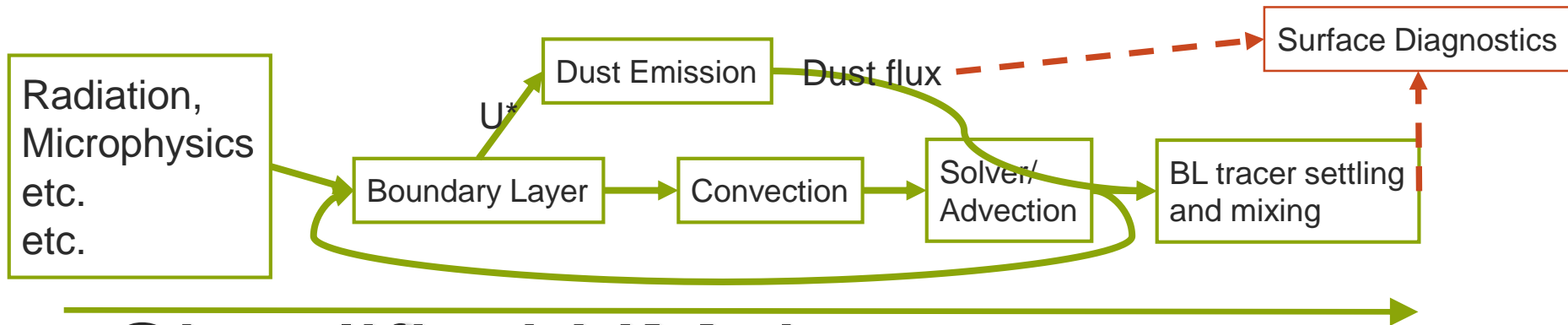
Diurnal cycle of surface diagnostics

Issue identified by GALWEM Dust Evaluation *(Sedlacek, Craig, Bliujus)*

1. Ex-Ophelia bringing a dust plume with her
2. *Surface* dust concentration and Vis have a diurnal pulse
3. The Dust AOD does not have diurnal signal
4. Lack severe dust Vis events (and AOD extremes).

Diurnal cycle of surface diagnostics

- Surface dust diagnostics affected, column/upper level are not.

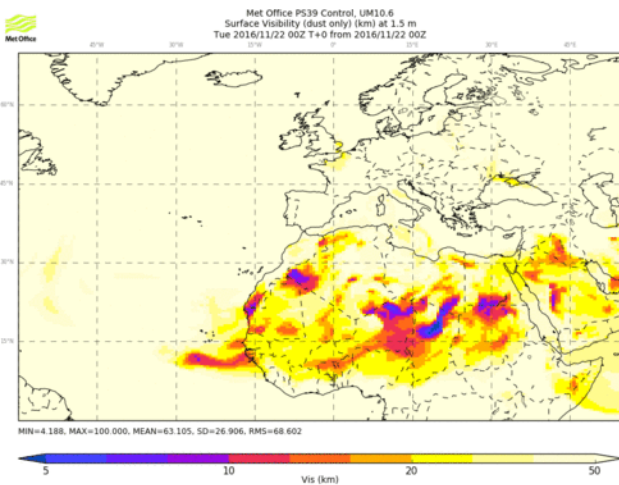- Indicates a possible cause and fix:
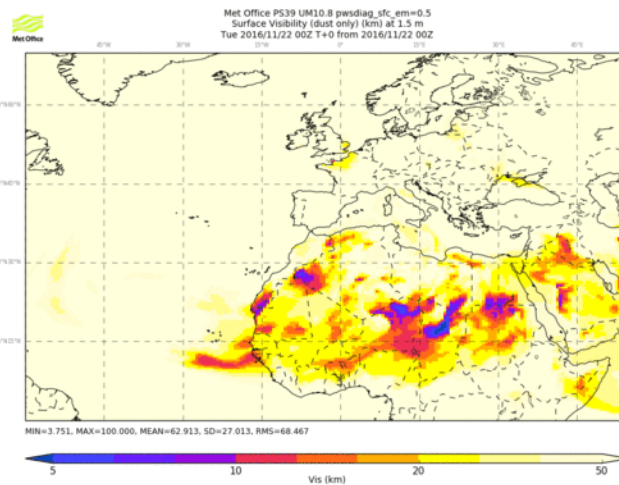

Simplified UM timestep:

Diagnostic only change: no impact on actual dust fields

simpler to switch on

diurnal cycle still in 3D fields

- does that need fixing?
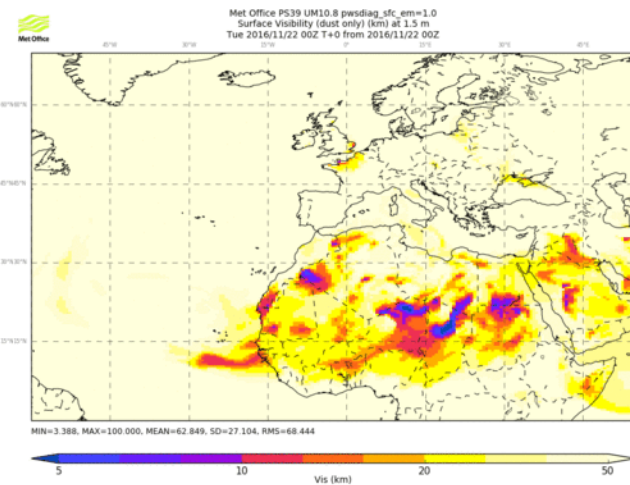
Diurnal cycle of surface diagnostics

- Surface dust diagnostics affected, column/upper level are not.

- Indicates a possible cause and fix:

100% end of TS

50% emission
50% end of TS

100% emission

Diurnal cycle of surface diagnostics

- Surface dust diagnostics affected, column/upper level are not.

- Indicates a possible cause and fix:

Mean +- Std.Dev.

Minimum vis.

Diurnal cycle in 15W-60E, 0-30N region

Legend:
- UM10.6, N320 glm
- UM10.8 pwsdiag_sfc_em=0.5
- UM10.8 pwsdiag_sfc_em=1.0
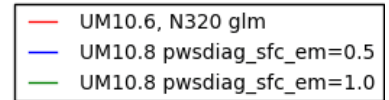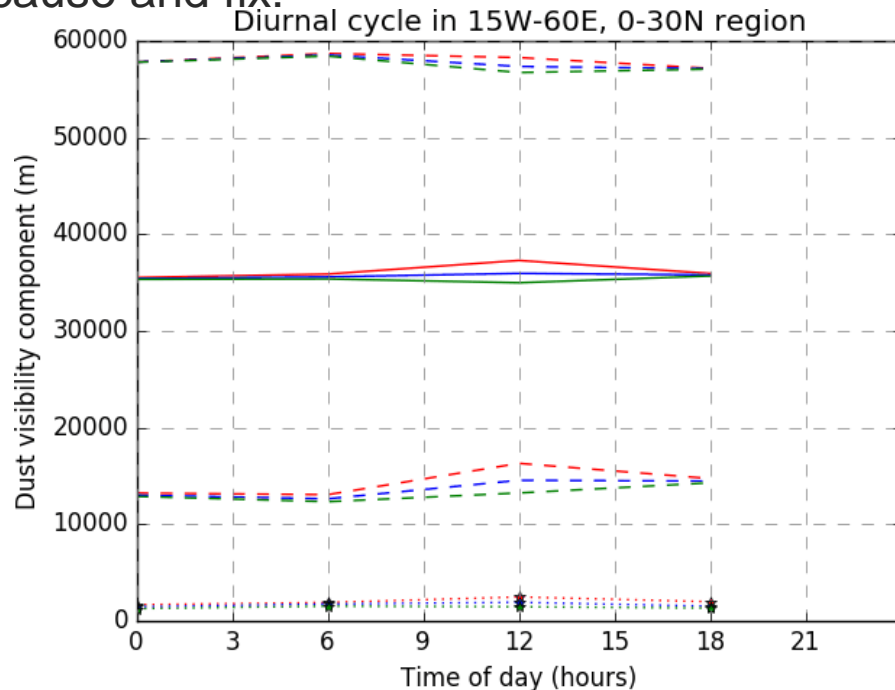
X-axis: Time of day (hours)
Y-axis: Dust visibility component (m)

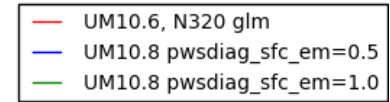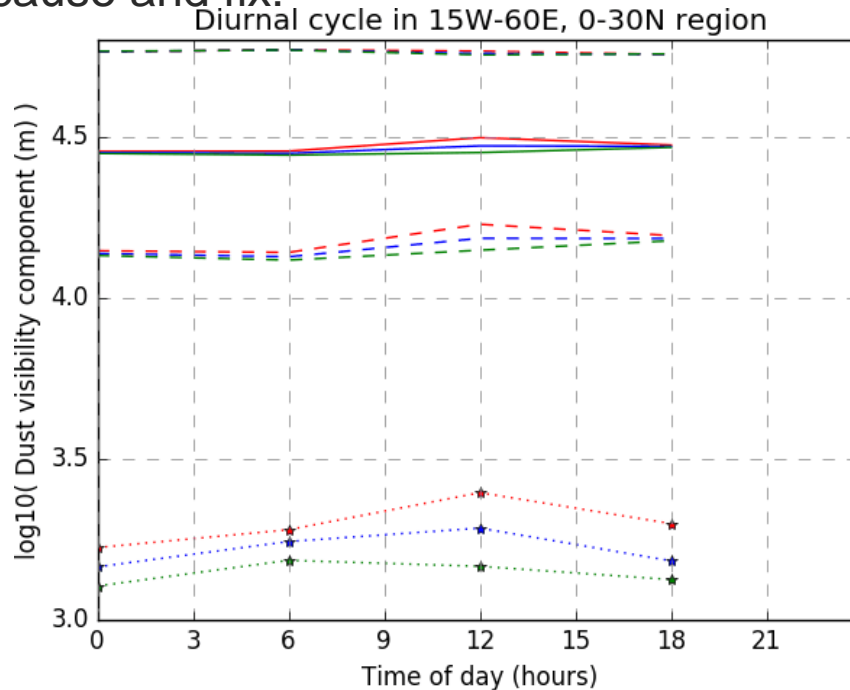# Diurnal cycle of surface diagnostics

- Surface dust diagnostics affected, column/upper level are not.

- Indicates a possible cause and fix:

Mean +- Std.Dev.

Minimum vis.

Diurnal cycle in 15W-60E, 0-30N region

Legend: UM10.6, N320 glm; UM10.8 pwsdiag_sfc_em=0.5; UM10.8 pwsdiag_sfc_em=1.0

y-axis: log10(Dust visibility component (m))

x-axis: Time of day (hours)

Duirnal cycle and peak AOD retune

Objectives

- Dust events to contain higher peak AOD (and lower min Vis)
  - AERONET and VIS obs show poor frequency bias for these events

- Mean dust AOD to increase at long lead times (to match analyses)
  - If background dust AOD increases, so might the analyses.
  - AOD is what is observed in DA, so needs to be consistent

- Change the amount of BL vertical mixing to fix diurnal cycle *(Glenn Creighton, USAF)*
  - BL mixing applied to all aerosols in the UM.
  - Mixes through BL depth - sensible with 30 minute climate timestep? With a 4 minute NWP timestep?
  - Not a diagnostic, what does this do to long range transport?

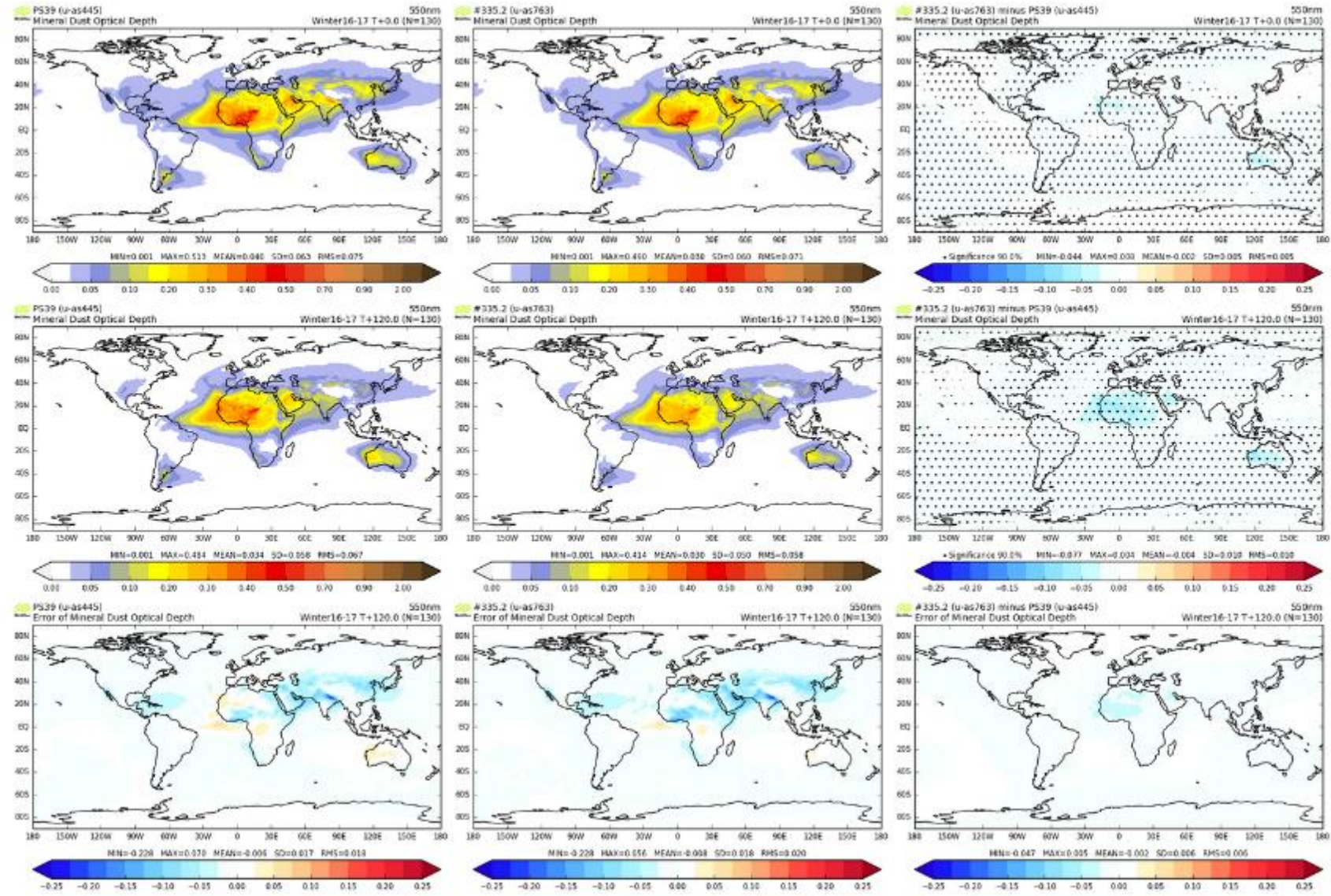# Duirnal cycle and peak AOD retune

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- Mean dust AOD to increase at long lead times (to match analyses)
  - If background dust AOD increases, so might the analyses.
  - AOD is what is observed in DA, so needs to be consistent

- Tuning knobs already exist:
  - reduce scaling of U* before emission (dust emission less frequent)
  - Increase scaling on emitted dust (so more is emitted when it happens)

- Change the amount of BL vertical mixing to fix diurnal cycle
  - Not a diagnostic, what does this do to long range transport?
  - A new tuning knob: scales the vertical mixing in the Boundary layer scheme.

Duirnal cycle and peak AOD retune
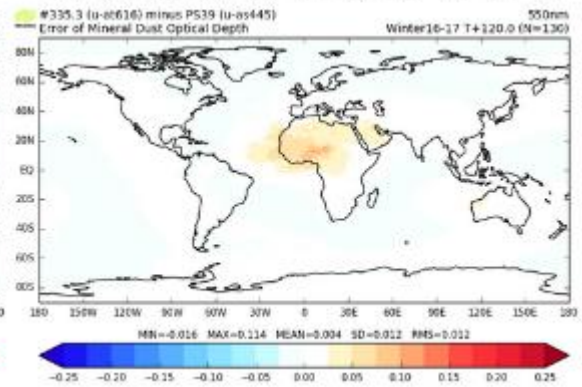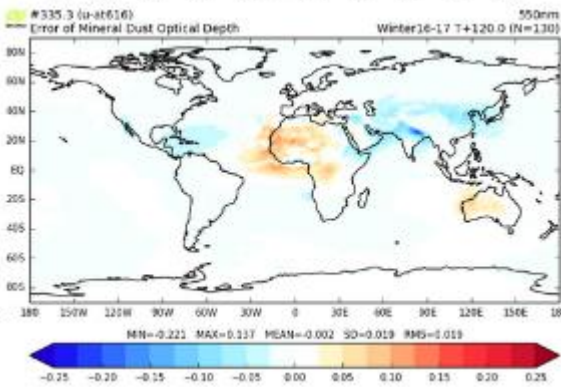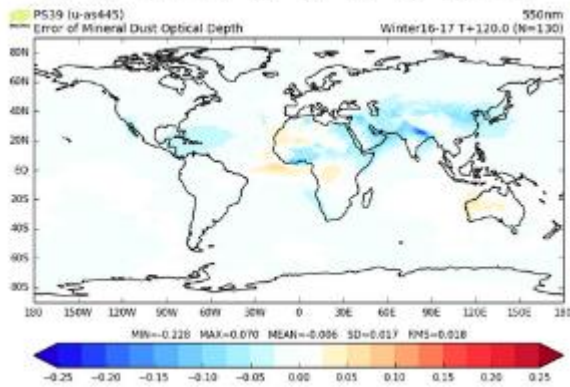

An, T+0 F'cast Error

Control Test Difference

Duirnal cycle and peak AOD retune

Objectives

- Higher peak AOD, but consistent mean state with analysis

- Tuning knobs already exist:

  - reduce scaling of U* before emission (dust emission less frequent)

  - Increase scaling on emitted dust (so more is emitted when it happens)

PS39 control: us_am=2.20, horiz_d=0.7

#335.2: us_am=1.5, horiz_d=1.0   -   Negative AOD bias

Duirnal cycle and peak AOD retune

An, T+0   F'cast Error

Control   Test   Difference
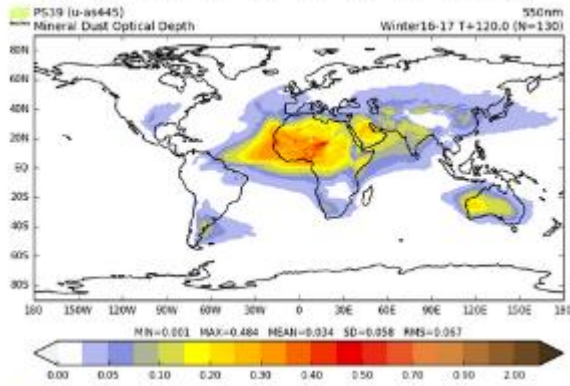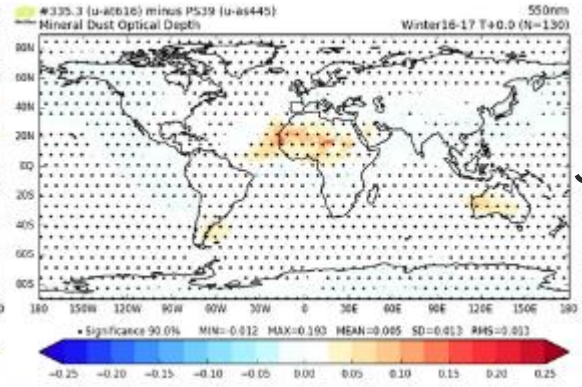
Duirnal cycle and peak AOD retune

Objectives

- Higher peak AOD, but consistent mean state with analysis
- Tuning knobs already exist:
  - reduce scaling of U* before emission (us_am)
  - Increase scaling on emitted dust (horiz_d)

PS39 control: us_am=2.20, horiz_d=0.7

#335.2: us_am=1.5, horiz_d=2.0 : Not enough dust, -ve AOD bias

#335.3: us_am=1.5, horiz_d=4.0 : Too much dust, +ve AOD bias

Duirnal cycle and peak AOD retune

An,T+0 F'cast Error

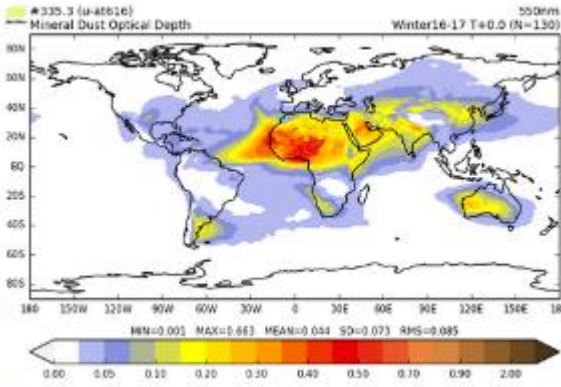Control   Test   Difference

Duirnal cycle and peak AOD retune
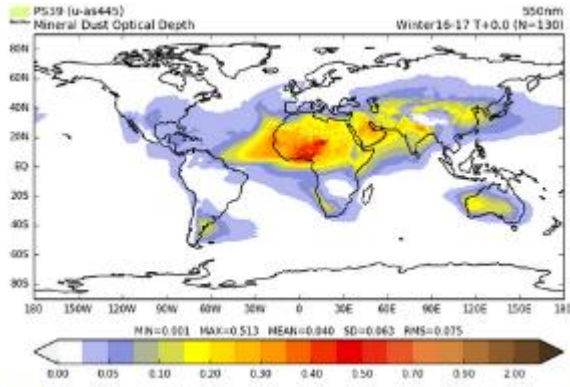
Objectives

- Higher peak AOD, but consistent mean state with analysis
- Tuning knobs already exist:
  - reduce scaling of U* before emission (us_am)
  - Increase scaling on emitted dust (horiz_d)

PS39 control: us_am=2.20, horiz_d=0.7

#335.2: us_am=1.5, horiz_d=2.0 : Not enough dust, -ve AOD bias

#335.3: us_am=1.5, horiz_d=4.0 : Too much dust, +ve AOD bias

#335.6: us_am=1.5, horiz_d=0.4, BL mixing scaled by 0.5: bias sweetspot

   but diurnal cycle better with 0.01 *(Glenn Creighton, USAF)*

Duirnal cycle and peak AOD retune

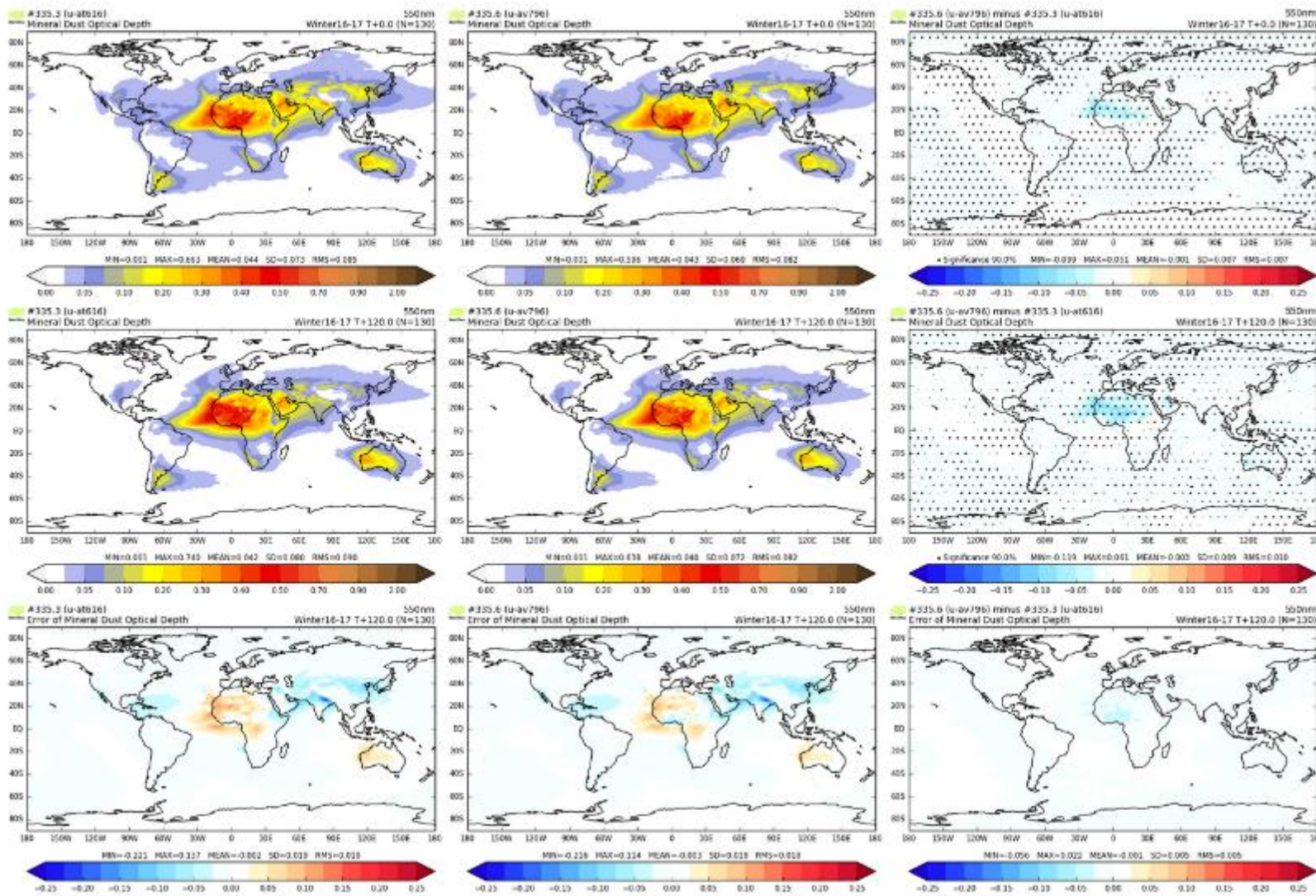An, T+0 F'cast Error

Control   Test   Difference

Objectives

- Higher peak AOD, but consistent mean state with analysis
- Tuning knobs already exist:
  - reduce scaling of U* before emission (us_am)
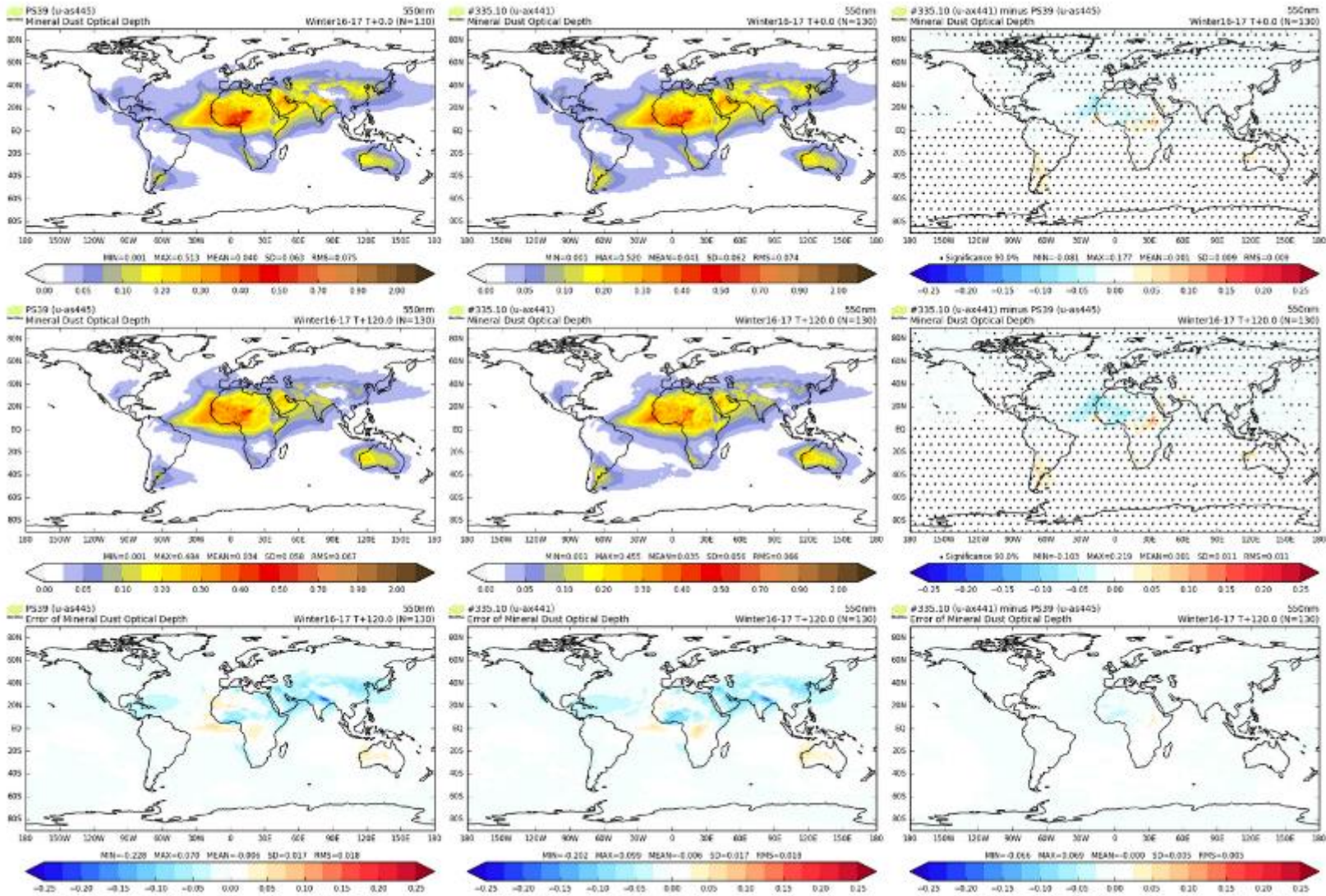 - Increase scaling on emitted dust (horiz_d)

PS39 control: us_am=2.20, horiz_d=0.7

#335.2: us_am=1.5, horiz_d=2.0 : Not enough dust, -ve AOD bias

#335.3: us_am=1.5, horiz_d=4.0 : Too much dust, +ve AOD bias

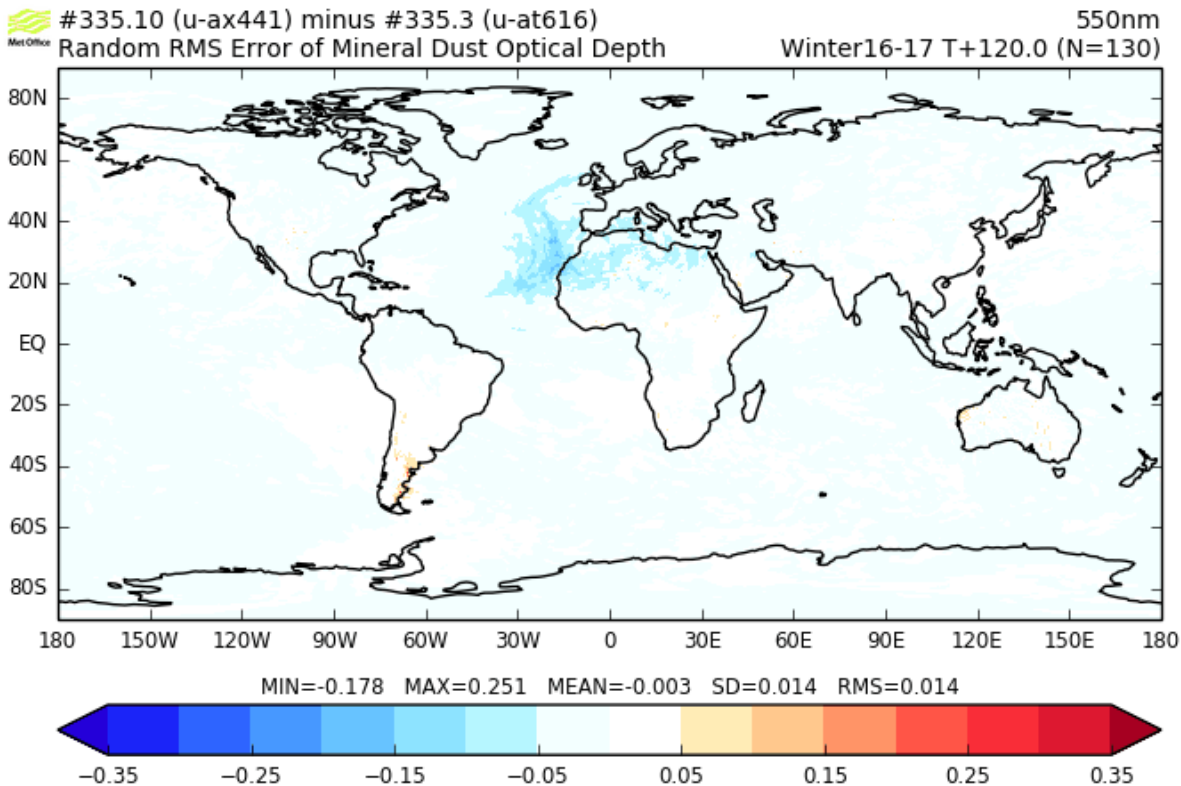#335.6: us_am=1.5, horiz_d=0.4, BL mixing scaled by 0.5: bias sweetspot

    but diurnal cycle better with 0.01 *(Glenn Creighton, USAF)*

#335.6: BL mixing x0.01:   dust deposition too active, -ve bias

Duirnal cycle and peak AOD retune

What is the impact of reducing BL mixing:

#335.6: BL mixing x0.01:   dust deposition too active, -ve bias

After removing the bias, long range transport improved!

Duirnal cycle and peak AOD retune

Equitable threat score vs AERONET L1.5 AOD observations at 550nm, with AOD threshold, at T+120
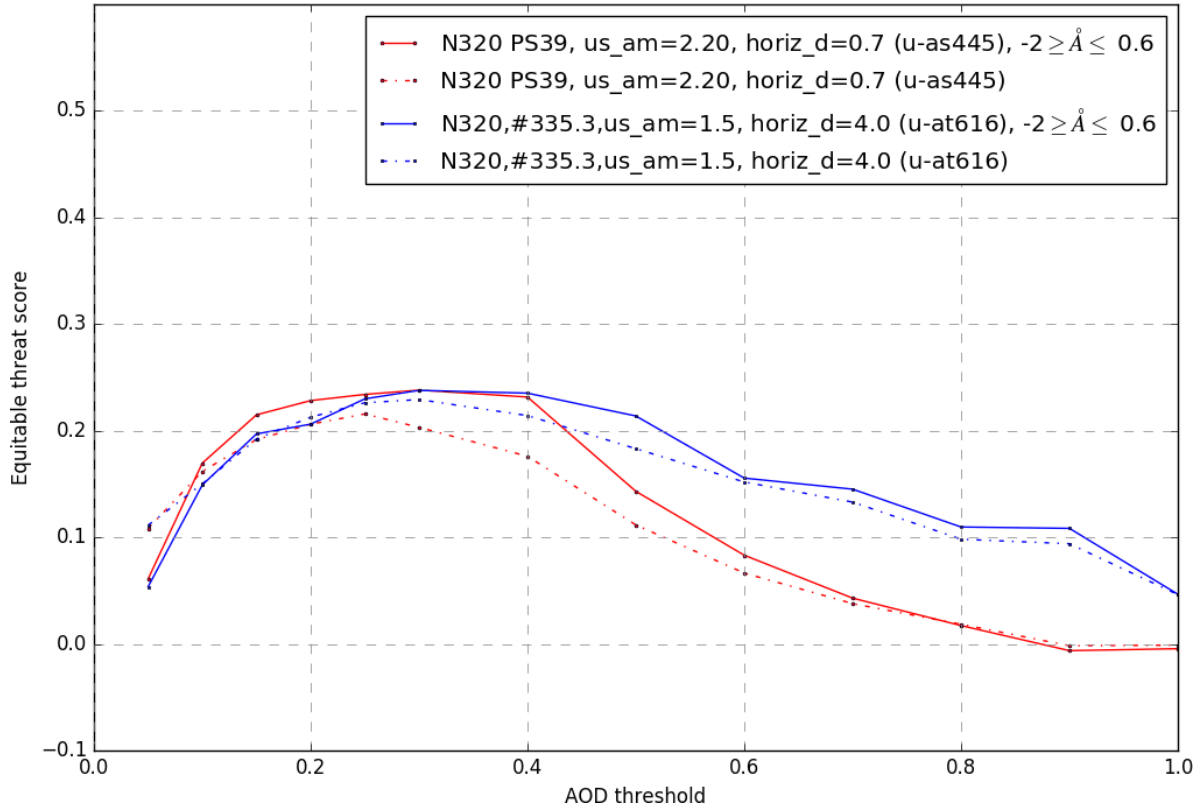
#335.5 (tuning, no BL mix): Large improvement vs AERONET

Equitable threat score vs AERONET L1.5 AOD observations at 550nm, with AOD threshold, at T+120

#335.5 (tuning, no BL mix): Large improvement vs AERONET

BL mixing 0.5 no change in skill

Duirnal cycle and peak AOD retune

Equitable threat score vs AERONET L1.5 AOD observations at 550nm, with AOD threshold, at T+120
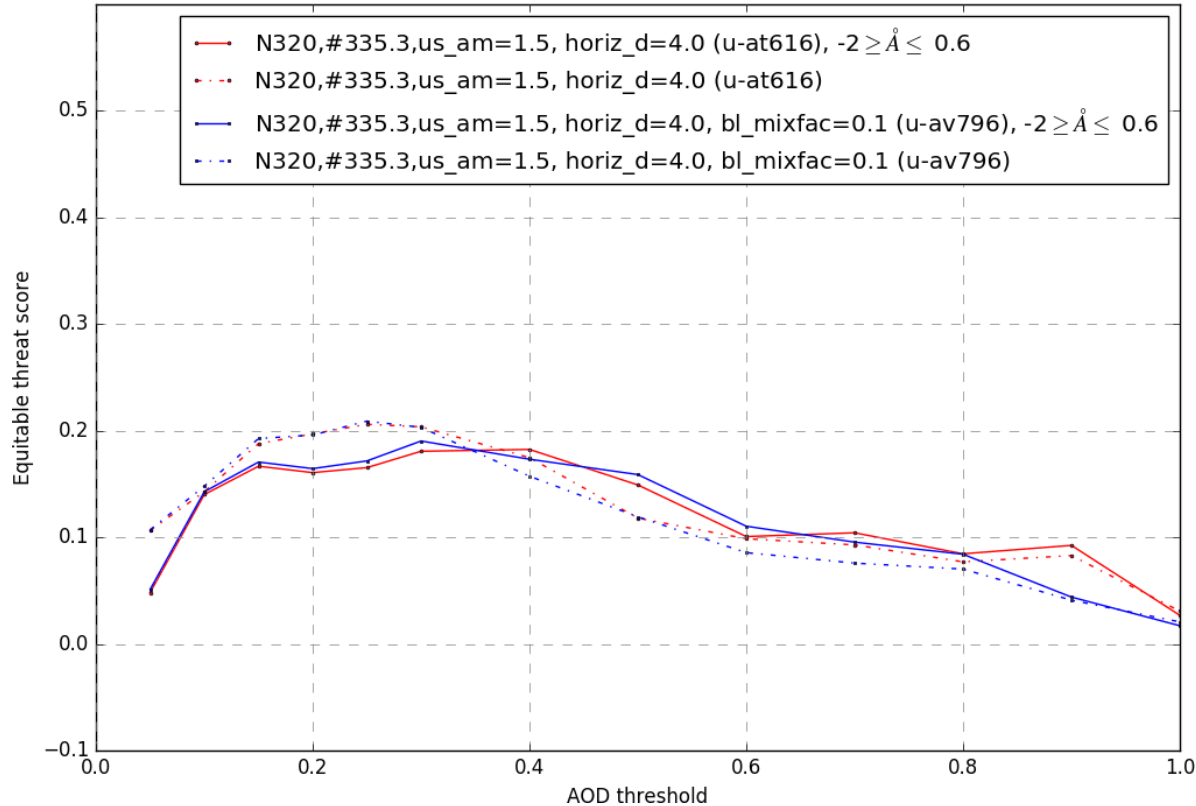
Legend:
- N320,#335.3,us_am=1.5, horiz_d=4.0 (u-at616), $-2 \geq \AA \leq 0.6$
- N320,#335.3,us_am=1.5, horiz_d=4.0 (u-at616)
- N320,#335.3,us_am=1.5, horiz_d=4.0, bl_mixfac=0.01 (u-ax441), $-2 \geq \AA \leq 0.6$
- N320,#335.3,us_am=1.5, horiz_d=4.0, bl_mixfac=0.01 (u-ax441)
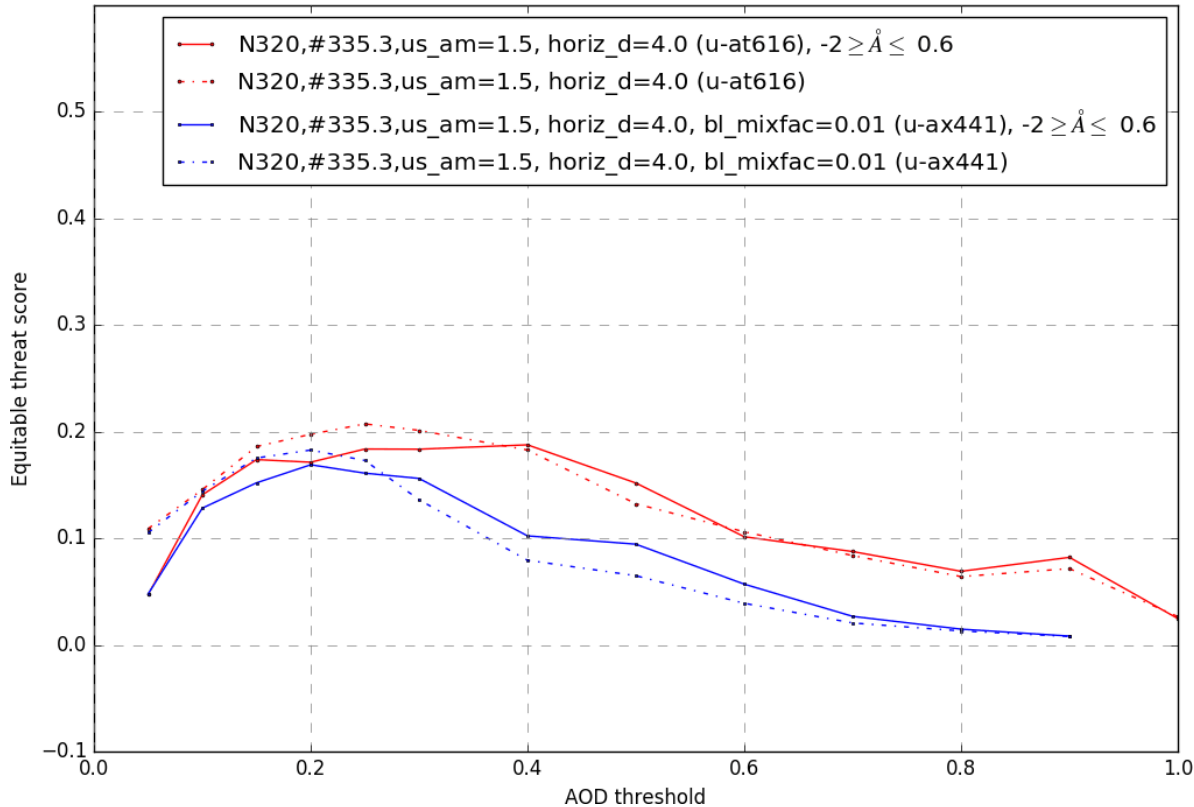
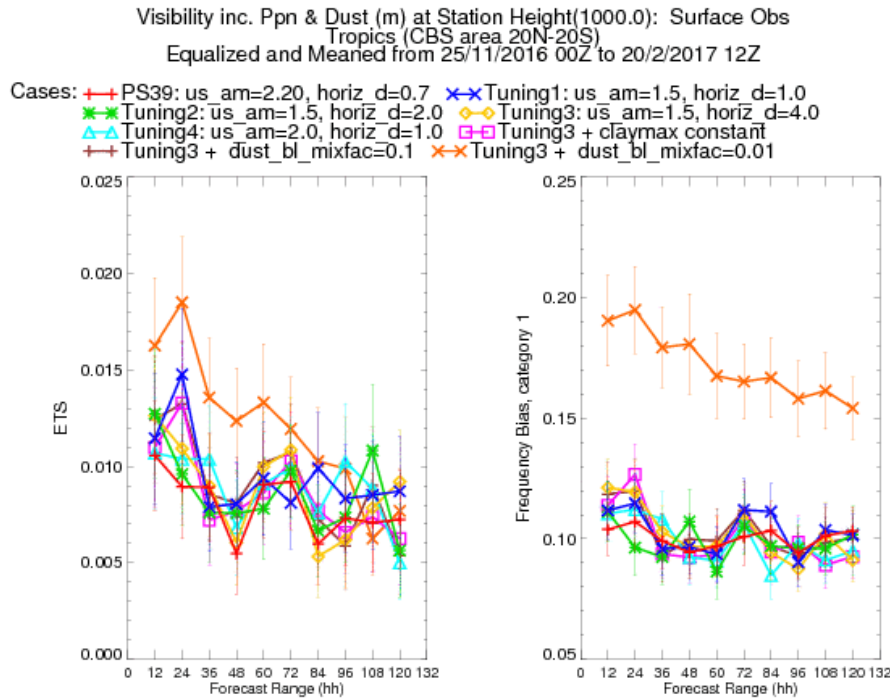#335.5 (tuning, no BL mix): Large improvement vs AERONET

BL mixing 0.1 no change in skill

BL mixing 0.01 reduces skill vs AERONET (bias impact is too much).

What is the impact of reducing BL mixing:

#335.6: BL mixing x0.01:   dust deposition too active, -ve bias

Visibility inc. Ppn & Dust (m) at Station Height(1000.0): Surface Obs
Tropics (CBS area 20N-20S)
Equalized and Meaned from 25/11/2016 00Z to 20/2/2017 12Z

Cases: ├─┤ PS39: us_am=2.20, horiz_d=0.7 ×─× Tuning1: us_am=1.5, horiz_d=1.0
×─× Tuning2: us_am=1.5, horiz_d=2.0 ◇─◇ Tuning3: us_am=1.5, horiz_d=4.0
△─△ Tuning4: us_am=2.0, horiz_d=1.0 □─□ Tuning3 + claymax constant
├─┤ Tuning3 + dust_bl_mixfac=0.1 ×─× Tuning3 + dust_bl_mixfac=0.01

Orange line – ETS skill score in Tropical VIS improved

Summary

1. Longstanding model issues – still there

2. New problems identified

    - Lack of peak dust AOD

    - Diurnal cycle in surface dust

3. Retuning exercise underway to address peak AOD

4. Broadly successful, when we include reduced BL mixing

    - An implementable change

5. Reduced BL mixing further has potential for further improvements, but needs more work.

Met Office

Questions and answers