1. Introduction and aims

- Composition data assimilation, the combination of models and satellite observations, in ECMWF’s C-IFS (Composition Integrated Forecast System) has led to ground-breaking new re- analyses & forecasts of global atmosphere composition.10
- Comparison to independent in-situ observations can test the accuracy of these re-analyses and identify any potential limitations in the “forward” global model. 71
- The 2012 SAMBBA (South American Biomass Burning Analysis) project involved aircraft and ground-based observations of a wide range of atmospheric constituents and aimed to assess the impacts from biomass burning emissions in the Amazon region, an area with traditionally sparse observation coverage.267

Aim: To quantify the effect of chemical assimilation on the Amazonian troposphere and validate the model and analysis, by comparing free-running and composition-assimilated C-IFS simulations to the SAMBBA observations made over the tropical biomass burning period.

2. Background: Biomass burning impact on O3 concentration

Amazon:
- Amazonian background tropospheric ozone ~20 ppb, some of the lowest concentrations on the planet.10
- This is due to isolation from anthropogenic NOx sources and deposition into the forest canopy.71
- Deposition of O3 into the forest canopy damages plant stomata, affecting photosynthesis.10
- Estimated annual forest sink for CO2 is 2.4 ± 0.7 g C yr⁻¹ (IPCC).

Biomass burning impacts:
- Significant concentrations of VOCs from burning and biogenic sources, make ozone concentrations sensitive to NOx.
- Increase in biomass burning emissions during the tropical 'dry season' (September-October), can show impacts of increased pollution.

3. C-IFS Experiments

Setup:
- Integrated MES models (week)
- T255 spectral resolution (0.7° x 0.7°)
- 60 Vertical levels
- Emission inventories: GFAS (Fire), MACCity (anthropogenic), MEGAN (biogenic) and POET (natural)
- GFAS uses FRP (fire radiative power) and emission factors to determine emissions.46
- Assimilated total columns: MOPITT CO, OMI O3 and NOx

Experiment list:
- Control: Meteorology assimilated
- Analysis: Composition and meteorology assimilated
- Control_NOB: Same as control but with no biomass burning emissions

4. SAMBBA

- Amazon flight campaign: September/October 2012.6
- Investigating the properties of biomass burning pollution in South America.
- Compared observations:
  - A19022: Fast fluorescence CO + TE149C: photometric O3

Flight phases:5:
- Western region (WR): tropical forest fires
- Eastern region (ER): cerrado (savanna) vegetation fires.

Phase 1: 04/09/12 - 22/09/12 (WR1): Representative of dry season
Phase 2: 23/09/12 - 03/10/1 (WR2): Transition to the wet season

5. Average column burdens: September/October 2012

Analysis
Analysis - Control
Analysis – Control
- Analysis of CO:
  - ER: Underestimated in the forward model. Bias is spatially homogeneous with larger increases generally seen where there is more background ozone e.g. the upper troposphere.
- CO2: Larger increase over the Amzon region.
- NOx: Largest increase over the cerrado region where NOx emissions are largest.

6. Vertical distribution

- CO: Small influence from assimilation, in fire dominated regions, both the forward model and the analysis capture observations well. Dry to wet transition captured more accurately than dry season.
- O3: Underestimated in the forward model: bias is spatially homogeneous with larger increases generally seen where there is more background ozone e.g. the upper troposphere.
- NOx: The large impact of assimilation shows NOx is significantly underestimated in the forward model.

4. SAMBBA profiles

WR1
WR2
ER

CO

Analysis
Control
NO BB emis

O3

Analysis
Control
NO BB emis

a. CO: Small influence from assimilation, in fire dominated regions, both the forward model and the analysis capture observations well. Dry to wet transition captured more accurately than dry season.

b. O3: Underestimated in the forward model: bias is spatially homogeneous with larger increases generally seen where there is more background ozone e.g. the upper troposphere.

c. NOx: Large increase over the Amazon region.

d. NOx: Largest increase over the cerrado region where NOx emissions are largest.

7. Conclusions

- In these polluted fire regions, model and analysis underestimate O3, this is contrary to the overestimation seen in surface studies such as Pacoﬁco et al. (2015)10.
- Increase in O3 due to fire emissions from eastern (~20 ppb) and western region (~10 ppb), even when the forward model underestimates O3, show the large impact of NOx fire emissions on O3.
- CO is captured more accurately in the wet to dry transition, where there are fewer fires, suggesting larger fires in the dry season are not resolved by the forward model.
- NOx changes the most significantly from assimilation. This change increases O3 concentrations in the eastern region, but is not sufficient to account for the bias compared to the in-situ observations.

8. References