# THE UNIVERSITY of York

# Iodine in the Troposphere

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## WHY IODINE?

**Iodine** is crucial for human health in diet; it perturbates the ozone budget & therefore impacts air-quality, crop yields and climate change. Reactive halogens (inc. iodine) catalytically destroy ozone through direct reaction followed by photolytic regeneration. In the troposphere this depletes ozone concentrations, decreasing the tropospheric long-wave absorption since ozone is a strong IR absorber. Of the halogens, the effect of bromine can now be considered by some global chemistry transport models (CTM) (Inc. GEOS-Chem), but the contribution of iodine cannot. The current understanding suggests that the combined impacts on ozone are greater than individual components [Read et al, 2008], & also with current uncertainties over sources [Sommariva et al, 2013; Carpenter et al, 2013] modelling can contribute to reconciling understanding & observations. Work is therefore being performed to introduce the current understanding of iodine chemistry into a established global CTM (GEOS-Chem), with the aim of developing the understanding of the role of iodine within the halogen-driven depletion of ozone & its broader impacts.

## BACKGROUND / OBSERVATIONS

- Difficult to detect the source species directly for reasons including short lifetimes & low concentrations
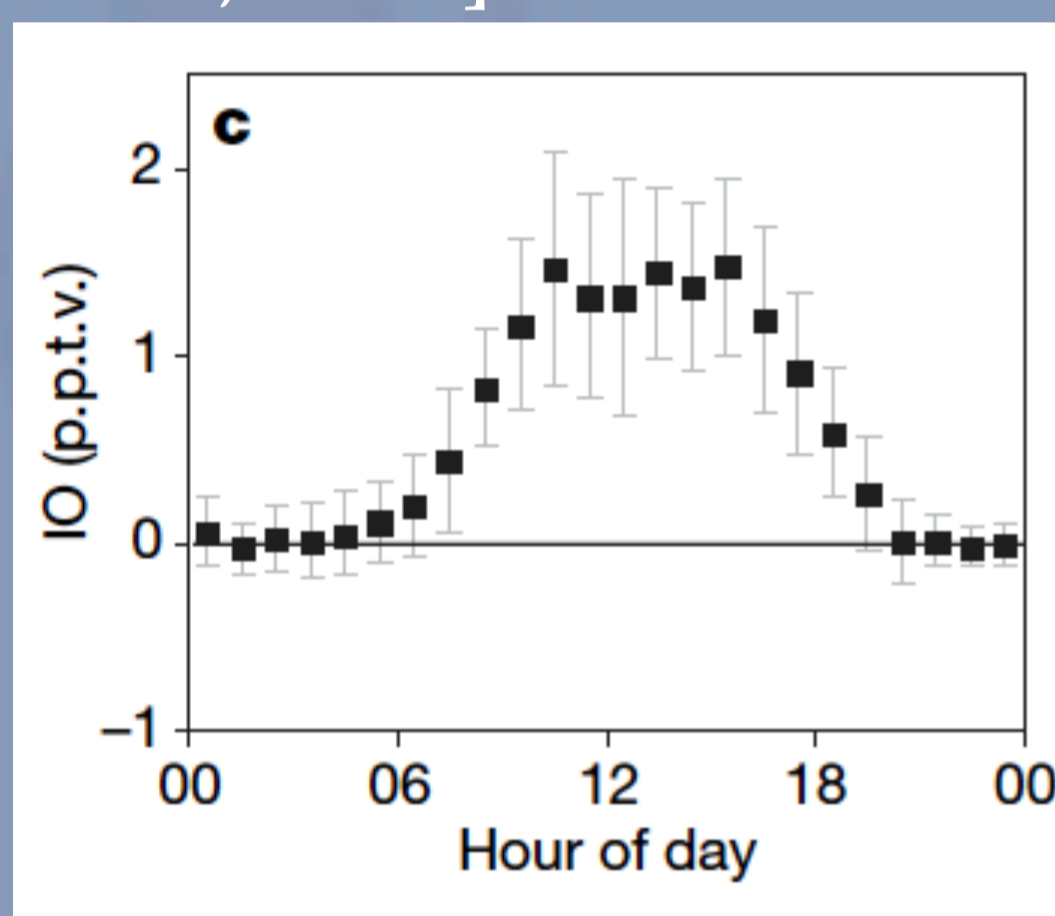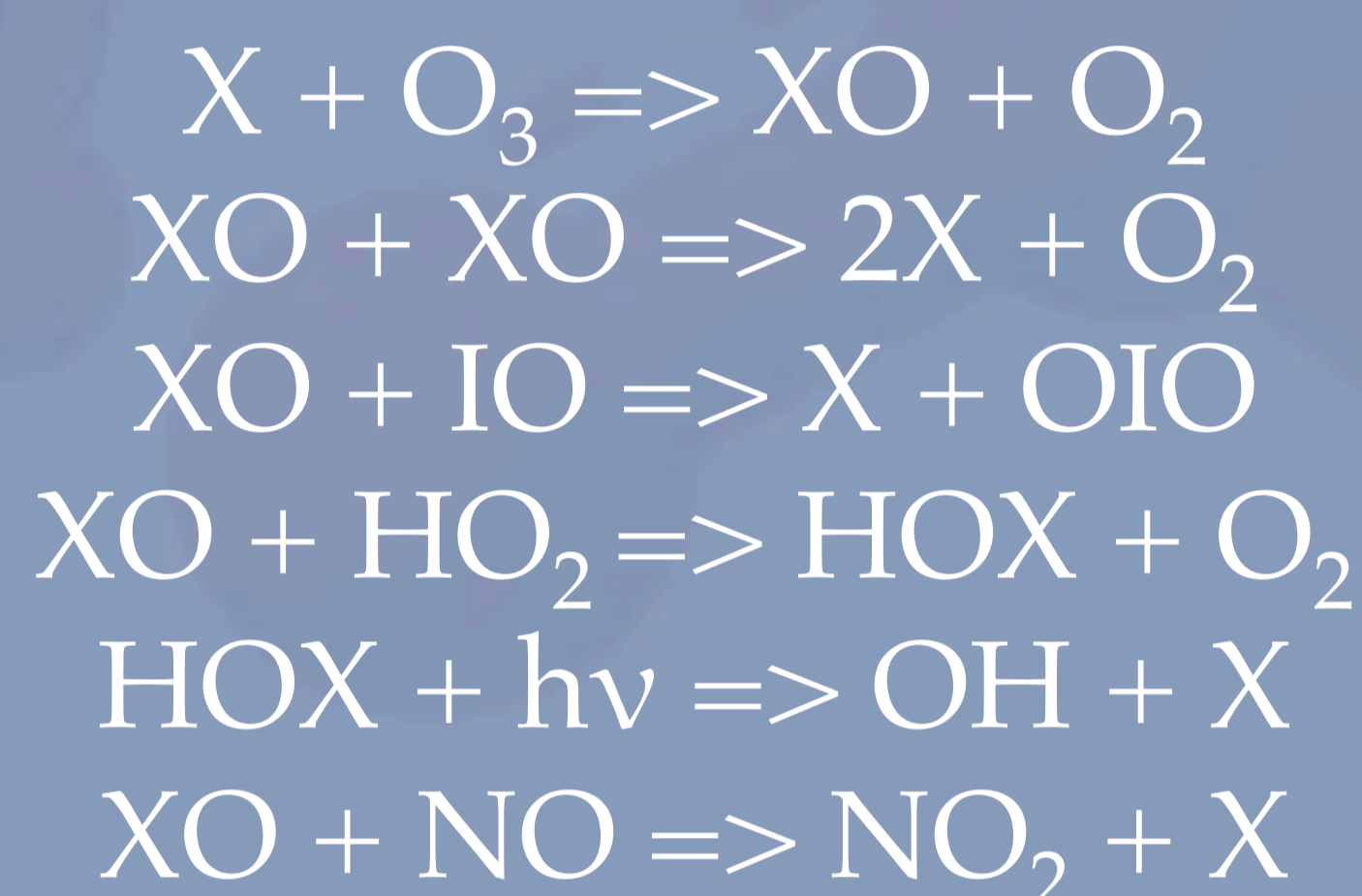- Oxidised species (e.g. IO) have been measured in the MBL with strong diurnal cycles (fig. 1) [Read et al, 2008]



**Figure 1:** Averaged diurnal profiles for a typical open ocean site, with $1\sigma$ errors. (Reproduced from: Read et al, 2008)

- Iodine also interacts with NOx & HOx cycles. A simplification of these reactions is shown below:

$$X + O_3 => XO + O_2$$
$$XO + XO => 2X + O_2$$
$$XO + IO => X + OIO$$
$$XO + HO_2 => HOX + O_2$$
$$HOX + h\nu => OH + X$$
$$XO + NO => NO_2 + X$$

## IODINE MODULE

The current knowledge has been compiled & written into a module for GEOS-Chem:

- Chemistry:  *Gas-Phase & Aersol*
Reactions schemes have been compiled from existing knowledge inc.: [Sommariva et al, 2012; Perchtl et al, 2006; Vogt et al, 1999]

- Photolysis
Cross-sections from JPL [Sander et al, 2011, 2006] & prepared for Fast-J

- Dry & Wet deposition
Relevant species incorporated into existing GEOS-Chem approach [Wesley, 1989]

## EMISSIONS

- The majority of halogen emissions are oceanic in source
- A preliminary scheme has been imposed with set emission fluxes from oceanic gridboxes
- The scheme is a zonal extrapolation of observations by latitude, based on Jones et al, 2010
- Average values applied where no data is held
- Resultant observed concentrations are of expected order (fig. 2)
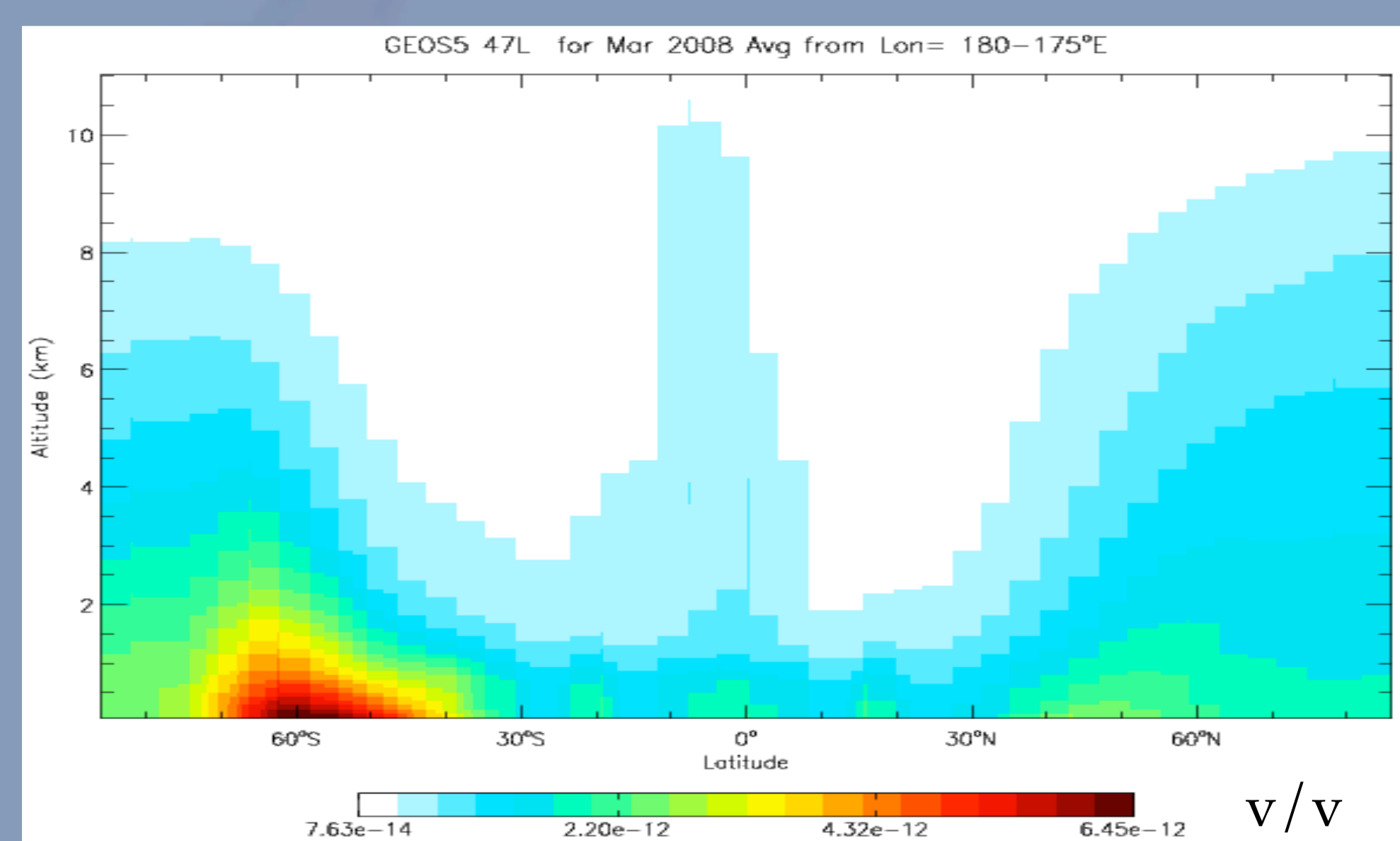


**Figure 2:** Averaged latitude profile of CH3I with altititude for model with set CH3I & CH2I2 fluxes run for lower 10km of atmosphere
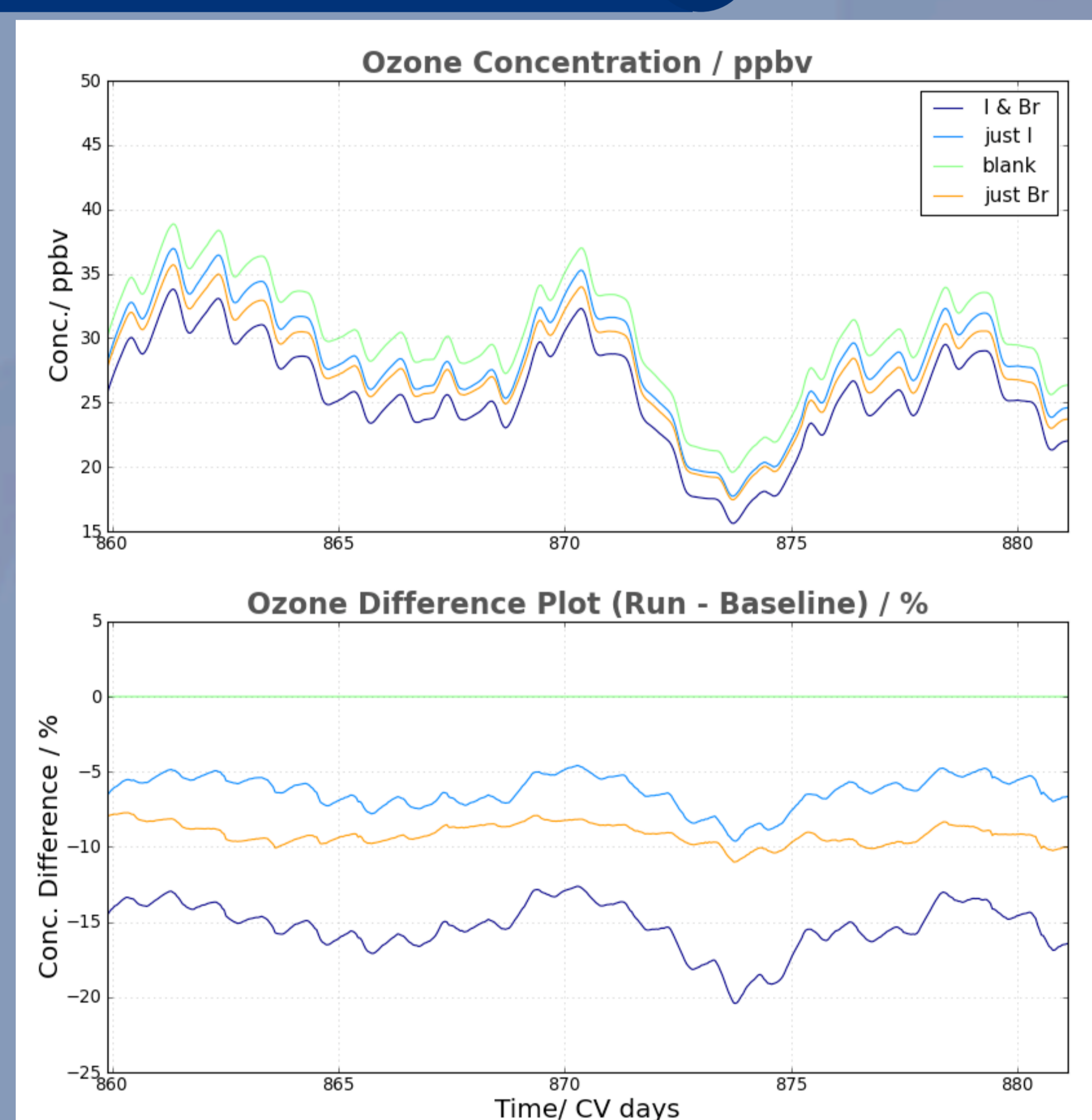
## PRELIMINARY DATA



**Figure 4:** Ozone depletion modelled at a typical open ocean site (Cape Verde) over a 3 week period in May 2008: baseline, green; just iodine, blue; just bromine, light blue; both, dark blue

- The model shows a spatial distribution limited to oceanic surface, as expected (fig. 3)
- Oxidised iodine (IO) shows total ocean coverage
- Antarctic maximum shown in other models has been replicated

- Depletion of ozone is clearly observable with the model (fig. 4)
- The joint impact of iodine & bromine on troposphere ozone is greater than either individual component
- The magnitude of ozone depletion for both species is of the order report by literature [Read, 2008]
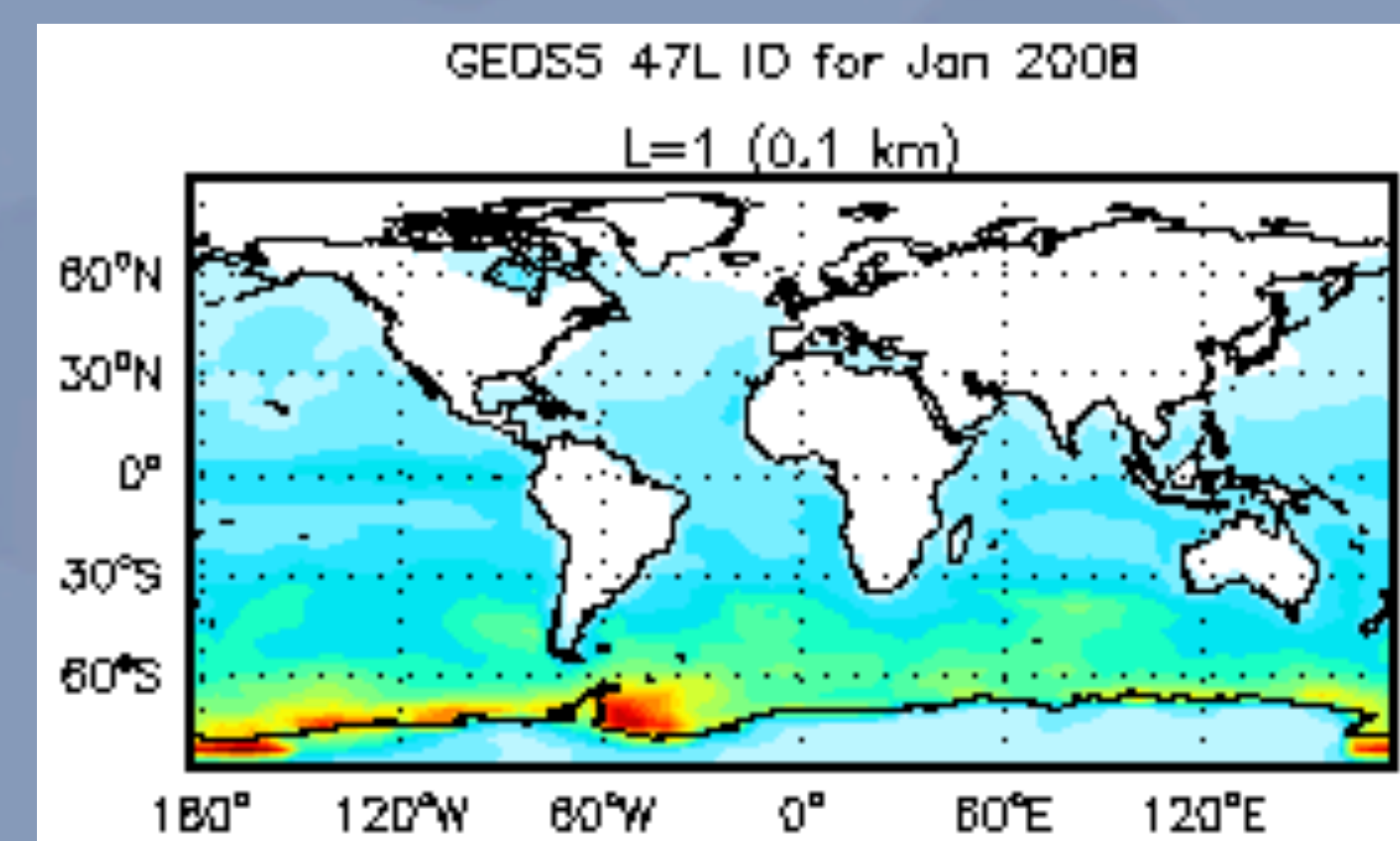- The values of IO being replicated by the model are still lower than those observed



**Figure 3:** IO distribution plot averaged over altitude fields

## CONCLUSIONS & FUTHER WORK

- The ozone depleting capability of iodine has been modelled within GEOS-Chem successfully
- Bromine & iodine combined have a greater effect than either in isolation
- This preliminary model data requires further sensitivity testing of deposition factors, photolytic rates, refining representation of chemistry and crucially, further development of the current approximated emissions scheme
- Experimental work to provide improved & further parameterisation of iodine sources species form the ocean surface
- Investigating evidence for hypothesised additional iodine sources on a global scale
- Quantifying implications on ozone budgets & mercury lifetimes

## ACKNOWLEDGEMENTS

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