Mechanistic Ocean-Atmosphere exchange of trace gases in Polar-WRF-Chem: Implications for Arctic tropospheric ozone

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Background & Objective

Dry deposition of ozone (O_3) to oceans in ACTMs* is often still represented with constant surface uptake resistances even though the role of physical and biogeochemical drivers results in substantial spatio-temporal variability in oceanic O_3 deposition.

Here, we investigate the impact of the model representation of oceanic O_3 deposition on the simulated magnitude of- and temporal variability in surface O_3 in the Arctic.

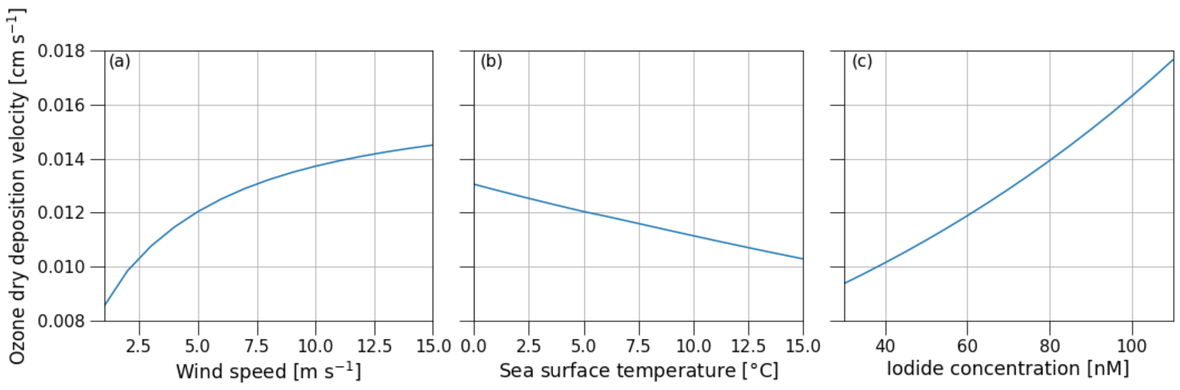


Fig. 1: Modelled sensitivity of ozone dry deposition velocity to physical and biogeochemical drivers for typical Arctic conditions.

We couple the COAREG[$] exchange routine to the Polar-WRF-Chem[#] model. In COAREG, the dry deposition velocity is calculated considering:

- Waterside turbulent transport (Fig. 1a)
- Solubility & molecular diffusivity (Fig. 1b)
- Chemical reactivity with oceanic Iodide (Fig. 1c)

Polar-WRF-Chem setup

- One month period
- End-of-summer 2008
- Evaluated for 25 sites (Fig. 2)
- Hourly mean surface O_3

Two model simulations

1. Using the commonly applied **CONSTANT** surface uptake resistance approach.
2. Using a mechanistic representation from **COAREG**.

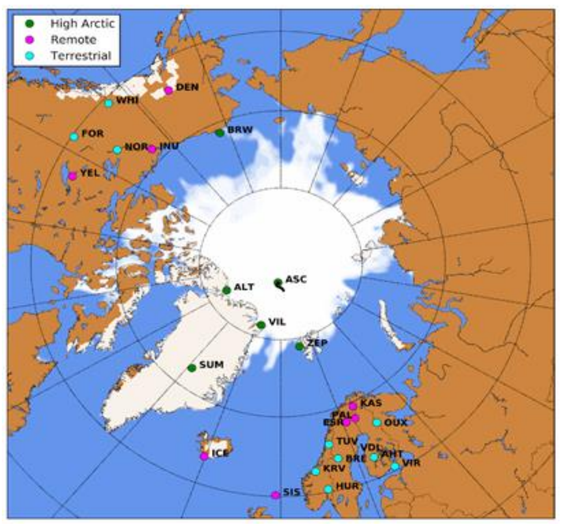


Fig. 2: Model domain & Observational sites

Results

Simulated oceanic O_3 deposition velocities are reduced from ~0.05 to ~0.01 cm s^{-1} and show more spatial variability (Fig. 3).

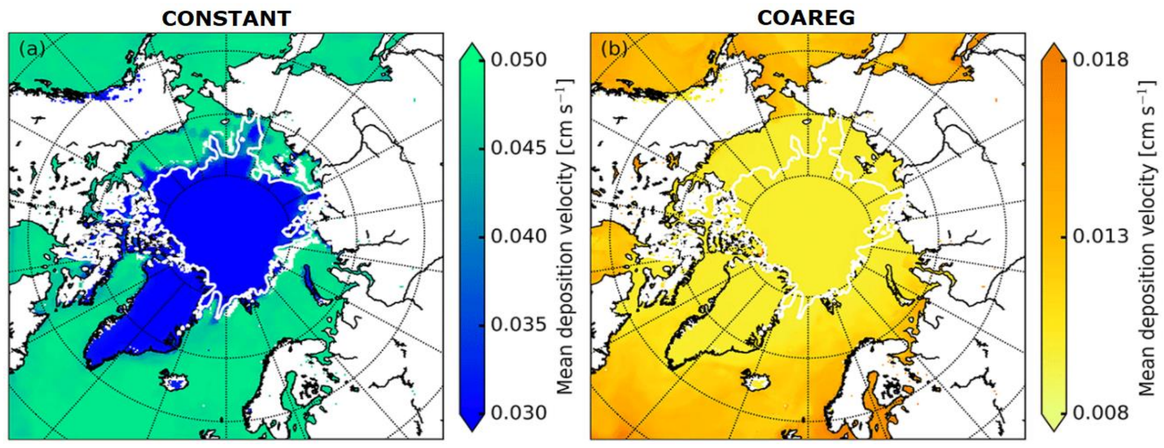


Fig. 3: Simulated O_3 deposition velocity for the CONSTANT and COAREG runs.

Reduced deposition velocities result in increased simulated O_3 concentrations across the Arctic. It is striking that, by accounting for environmental drivers, the observed temporal variability is better captured at Arctic sites such as ASCOS[&] (Fig. 4).

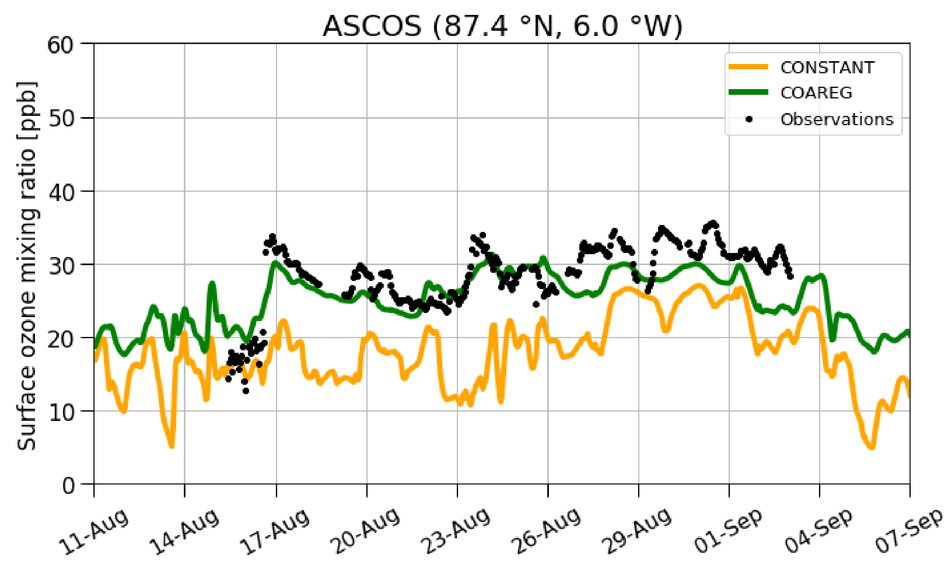


Fig. 4: Simulated and observed surface O_3 at ASCOS.

Conclusion

- *Using a mechanistic representation of oceanic O_3 depososition results in substantial reduction in simulated Arctic O_3 deposition.*
- *This results in a better representation of Arctic surface O_3 concentrations in terms of magnitude and temporal variability.*

- ACTMs = **A**tmospheric **C**hemistry and **T**ransport **M**odels
- [#] Polar-WRF-Chem = **Polar W**eather **R**esearching and **F**orecasting model coupled with **Chem**istry
- [$] COAREG = **C**oupled **O**cean-**A**tmosphere **R**esponse **E**xperiment **G**as transfer algorithm
- [&] ASCOS = **A**rctic **S**ummer **C**loud **O**cean **S**tudy

Reference:
Barten, J. G. M., Ganzeveld, L. N., Steeneveld, G.-J., and Krol, M. C.: Role of oceanic ozone deposition in explaining temporal variability in surface ozone at High Arctic sites, Atmos. Chem. Phys., 21, 10229–10248, https://doi.org/10.5194/acp-21-10229-2021, 2021

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