Modelling combined effects of ozone and climate stresses on Arctic and boreal species

UiO LATICE

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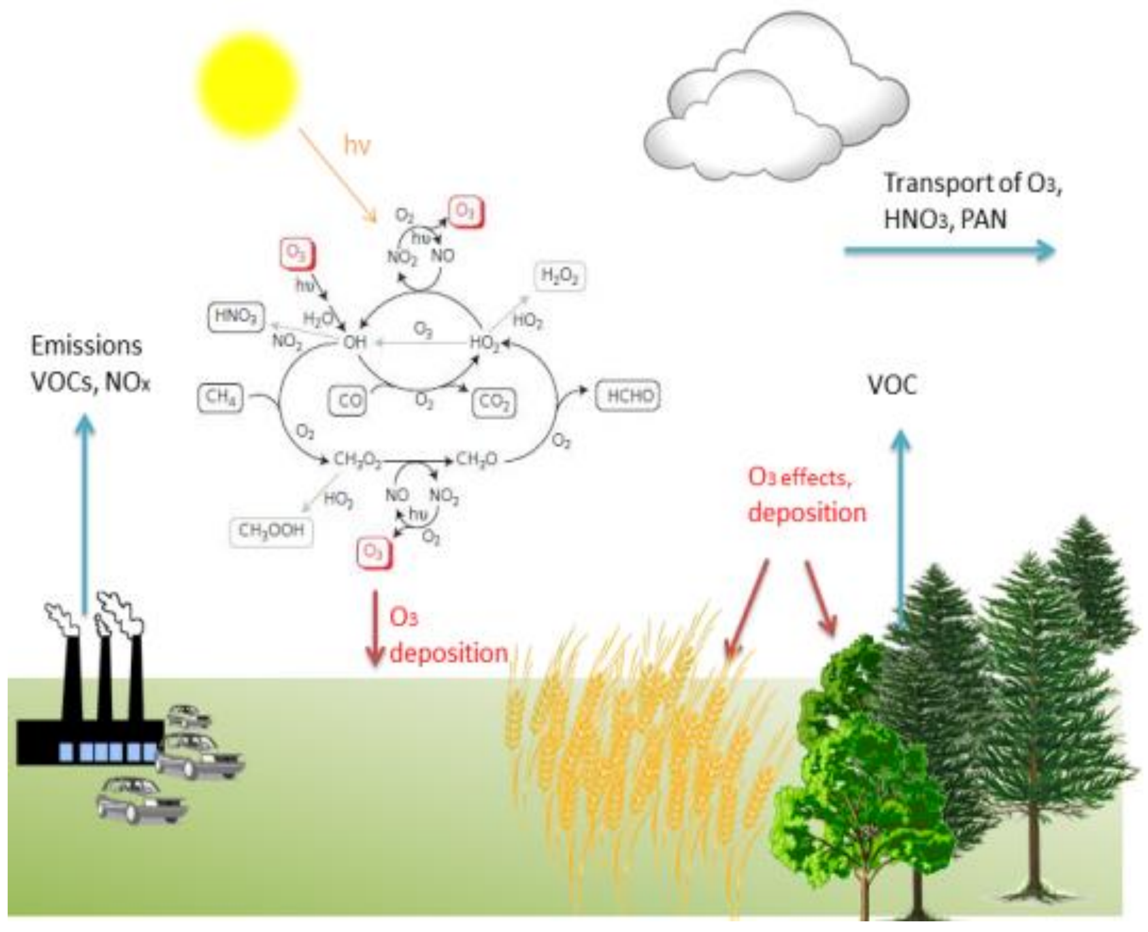
BACKGROUND

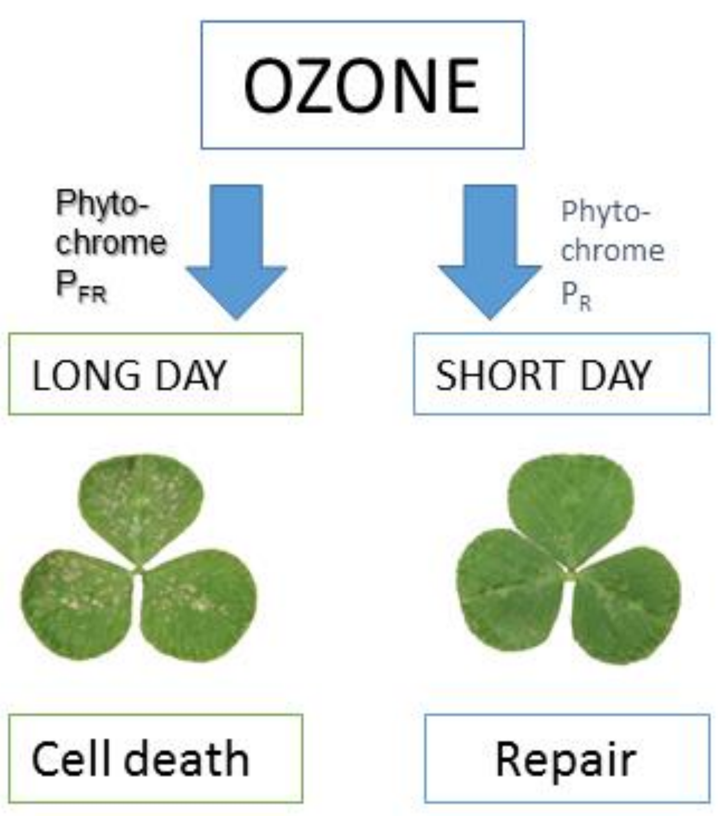
The project OzoNorClim will investigate combined effects of ozone and climate stresses on Arctic and boreal species. Interdisciplinary research questions are addressed, combining plant ecophysiology and atmospheric physics methods. The work consists of plant physiological and mycological experiments to quantify the effects of ozone polluted air under the particular conditions in Northern areas, and feeding the new information into widely used climate and tropospheric ozone injury models. The improved models will give a better representation of the interactions between tropospheric ozone, vegetation and climate in Arctic and tundra areas, and therefore a better foundation for political decisions.



Schematic pointing to impacts on plants when ozone is deposited in vegetation. Dominant features of tropospheric ozone production and loss mechanisms are shown in inset (adapted from The Royal Society (2008)).

OZONE IMPACTS IN LONG DAYS

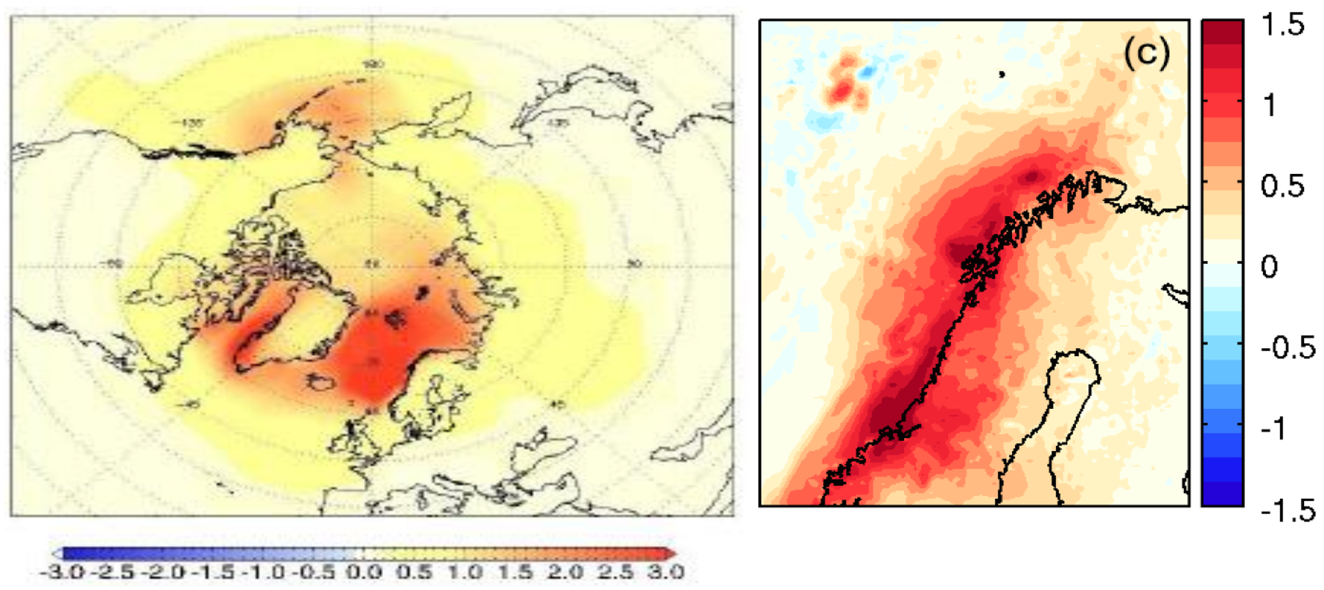
The midnight sun at the high latitude areas gives bright or dim summer nights, without darkness. For instance, in Alta (70 °N) there is 24 hr day (sun above horizon) in the period 17 May to 26 July (70 days), and the night is shorter than 10 h for 163 days . In our previous studies of three clover species (*Trifolium subterraneum, T. repens, T. pratense*) subjected to ozone combined with long-day conditions, we found that the ozone sensitivity increased, compared to plants grown in short-day conditions during ozone exposure (Vollsnes et al 2009; 2010, Futsaether et al 2015).



Effect of daylength on ozone sensitivity of subterranean clover showing that nighttime repair is inhibited during long days at high latitudes (based on Eriksen et al 2012).

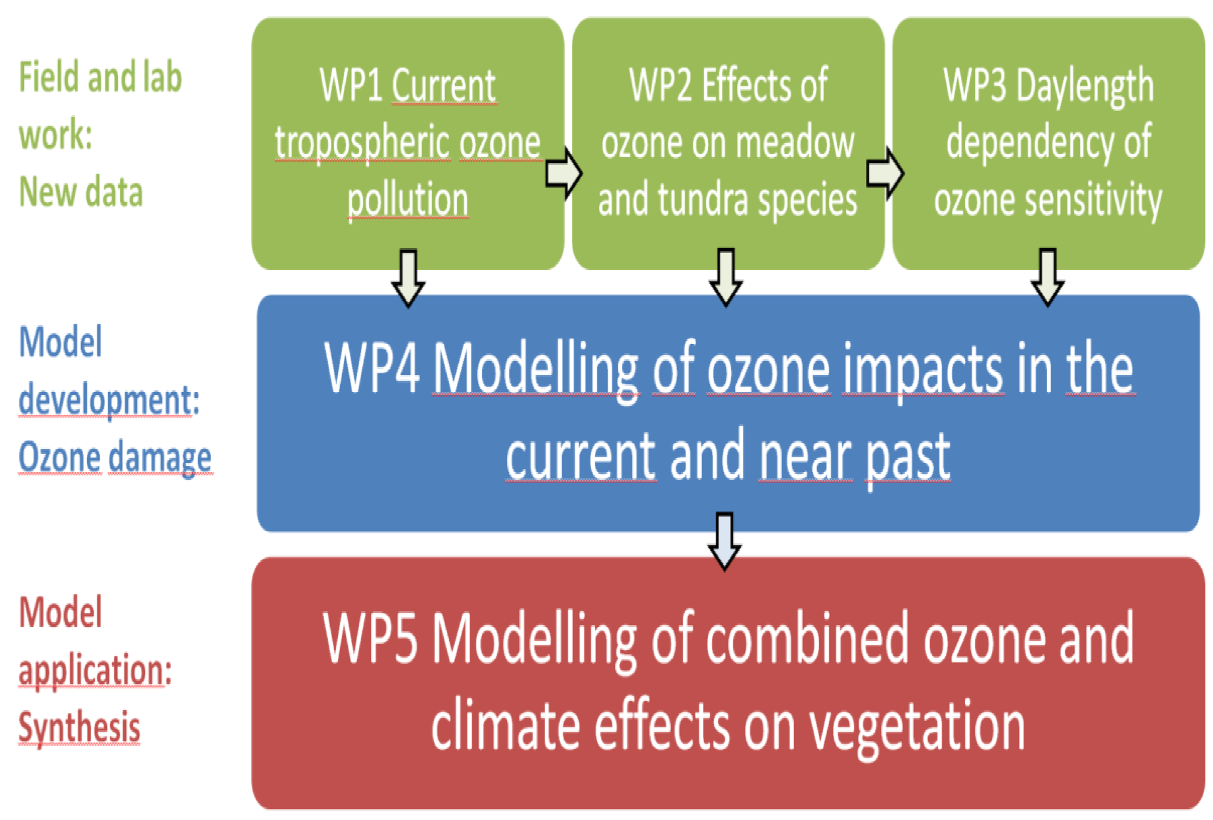
OZONE IN THE ARCTIC

With less sea ice in the Arctic Ocean, more ships are passing the coast of Northern Norway, causing increased emissions of ozone precursors, probably increasing the ozone exposure of the vegetation on land (Peters et al. 2011, Ødemark et al. 2012, Marelle et al. 2016).



Modelled O_3 change due to current Arctic shipping emissions. Left panel is for July-August September conditions (from Ødemark et al., 2012), based on an emission inventory (Peters et al., 2011), and right panel for a 15-days period in July 2012 when emissions were verified in an aircraft measurement campaign (Marelle et al., 2016). Values in both panels are in ppb.

OZONORCLIM PROJECT WORKFLOW



OZONORCLIM MODELLING FOCUS AND DESIGN

- Dynamical vegetation experiments will be made globally with the Norwegian Earth System model (NorESM), with the Community Land Model (CLM) land surface scheme and regionally with WRF-CLM. Focus is on expansion of shrubs into the Arctic and boreal zone and biophysical (albedo, surface energy and moisture fluxes) and biochemical (canopy and below ground carbon budget) feedbacks, in particular their role in Arctic amplification.
- Next, output from the climate simulations will be used as input to DO3SE to calculate the ozone uptake in plants under future climate conditions. The resulting ozone impacts on different types of vegetation will be mapped on the vegetation changes due to climate change alone.
- Finally, we will include a coupled version of DO_3SE and CLM in the NorESM model. We will perform experiments with the NorESM with nudging, for current climate and for future climate. This will allow us to quantify the effects on surface fluxes of energy, moisture and carbon due to the combined effect of ozone and climate change on vegetation. The simulations will provide a first order estimate of the importance of the coupled effects of ozone and climate driven vegetation changes.

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LATICE - Land Atmosphere Interactions in Cold Environments is a strategic research area at the University of Oslo. Regional (WRF) and global (NorESM) climate models are main tools. Main focus is on boreal and Arctic conditions

LATICE studies climate variability and change including feedbacks through:

- Improving parameterizations of processes in global earth system models controlling the interactions and feedbacks between the land surface and the atmosphere
- Assessing the influence of climate and land cover changes on water and energy fluxes
- Integrating remote earth observations with in situ data and suitable models to allow studies of finer scale processes governing land-atmosphere interactions

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