Two-year record of trace gas fluxes and dynamics in snowpack and soils

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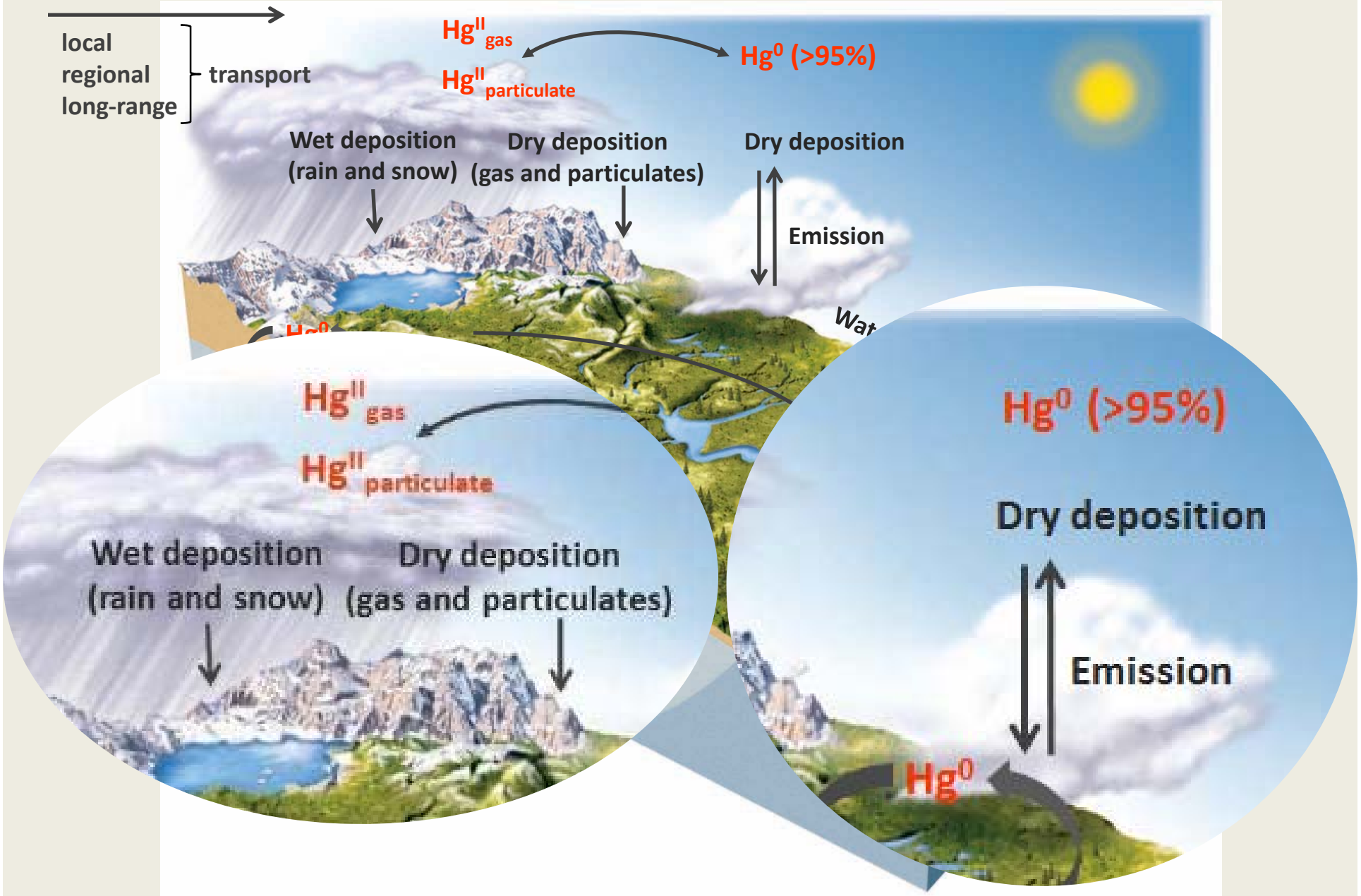
NSF PLR Project: Soil-Snow-Atmosphere Exchange of Mercury in the Interior Arctic Tundra Obrist & Helmig
DOE Office of Biological and Environmental Research Project: Yang, Obrist *et al.*

Goals

1. Constrain elemental cycling in the Arctic tundra
   - Contaminants: Hg, other trace metals
   - Trace gases: elemental Hg (Hg^0), O_3, NOx
   - GHG: CO_2 and CH_4
2. Trace gas exchange and dynamics:
   - Atmosphere-surface exchange using micrometeorological techniques
   - Atmosphere-snowpack-soil concentration profiles to quantify sink and sources
   - Temporal patterns including in mid-Arctic winter

Hg Cycling


local
regional
long-range
transport
Hg^{II}_{gas}
$Hg^{II}_{particulate}$
Hg^0 (>95%)
Wet deposition
(rain and snow)
Dry deposition
(gas and particulates)
Dry deposition
Emission
Hg^{II}_{gas}
$Hg^{II}_{particulate}$
Wet deposition
(rain and snow)
Dry deposition
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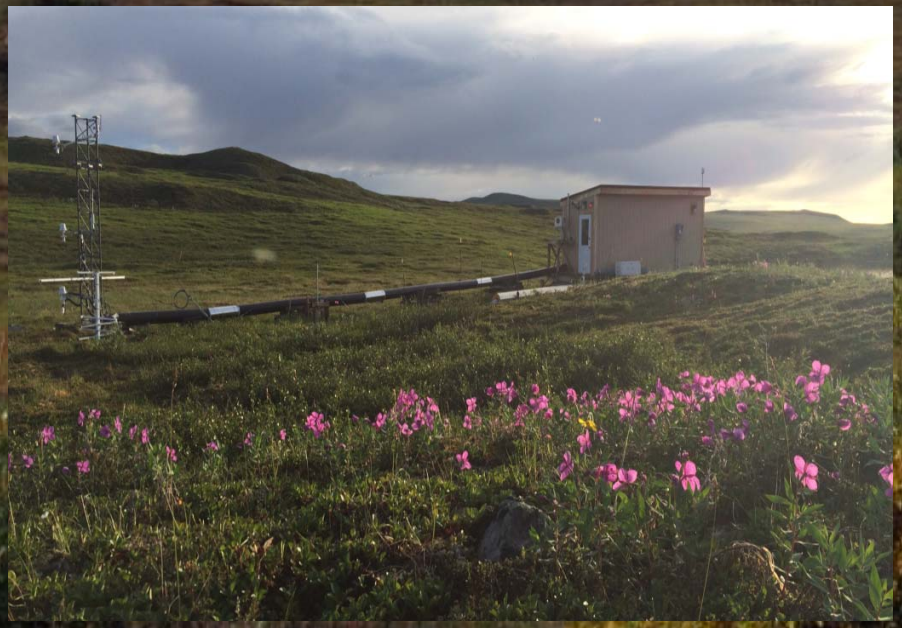
Hg^0 (>95%)
Dry deposition
Emission
Hg^0

Study Location – Toolik Field Station



Trace gas instrumentation – atmosphere

Net exchange (aerodynamic-MBR approach)

Elemental Hg^0 (Tekran 2537 Air Hg Analyzers)

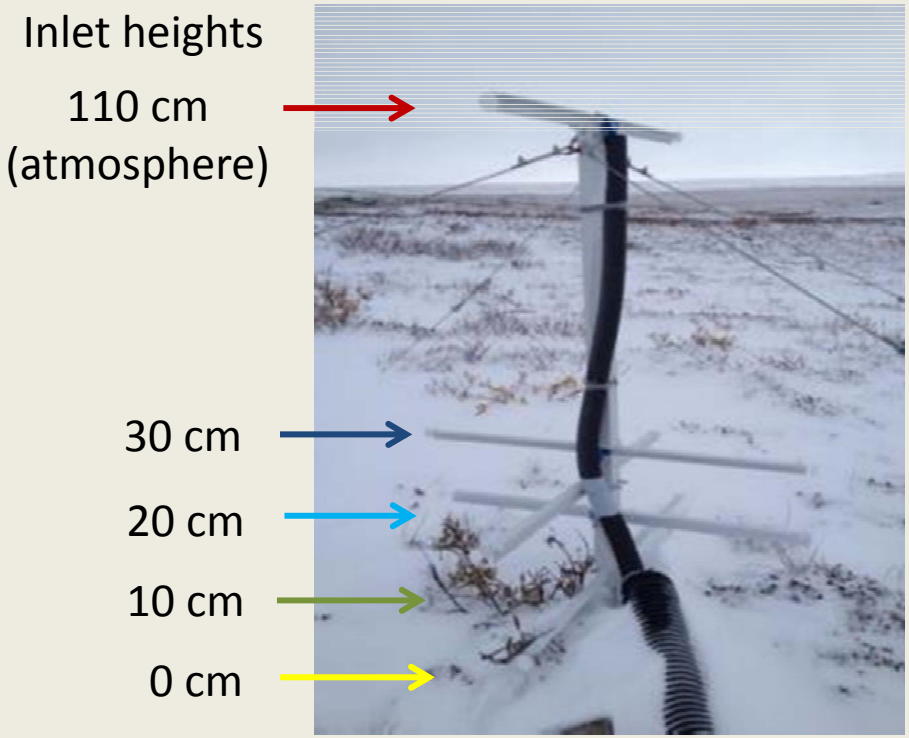
$CO_2/CH_4/H_2O$ Analyzers (LGR Inc.)

O_3/NOx Analyzers (Thermo Scientific)

Air temperature gradients, wind speed, RH, net radiation

Trace gas instrumentation – snow tower

Snow tower: measure snowpack gas concentration profiles (1 permanent over tundra, 1 seasonal over frozen lake)



Gaseous Hg^0 / CO_2 / CH_4 / H_2O / O_3 / NOx

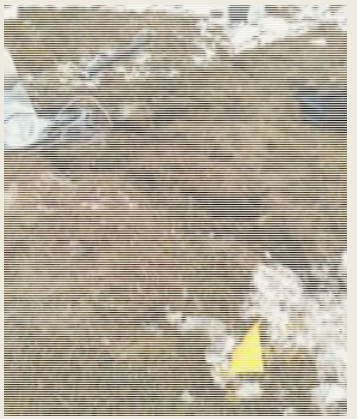
Trace gas instrumentation – soil wells

Soil wells: measure soil pore gas concentrations (3 soil depths [10, 20, 40 cm], 2 locations)





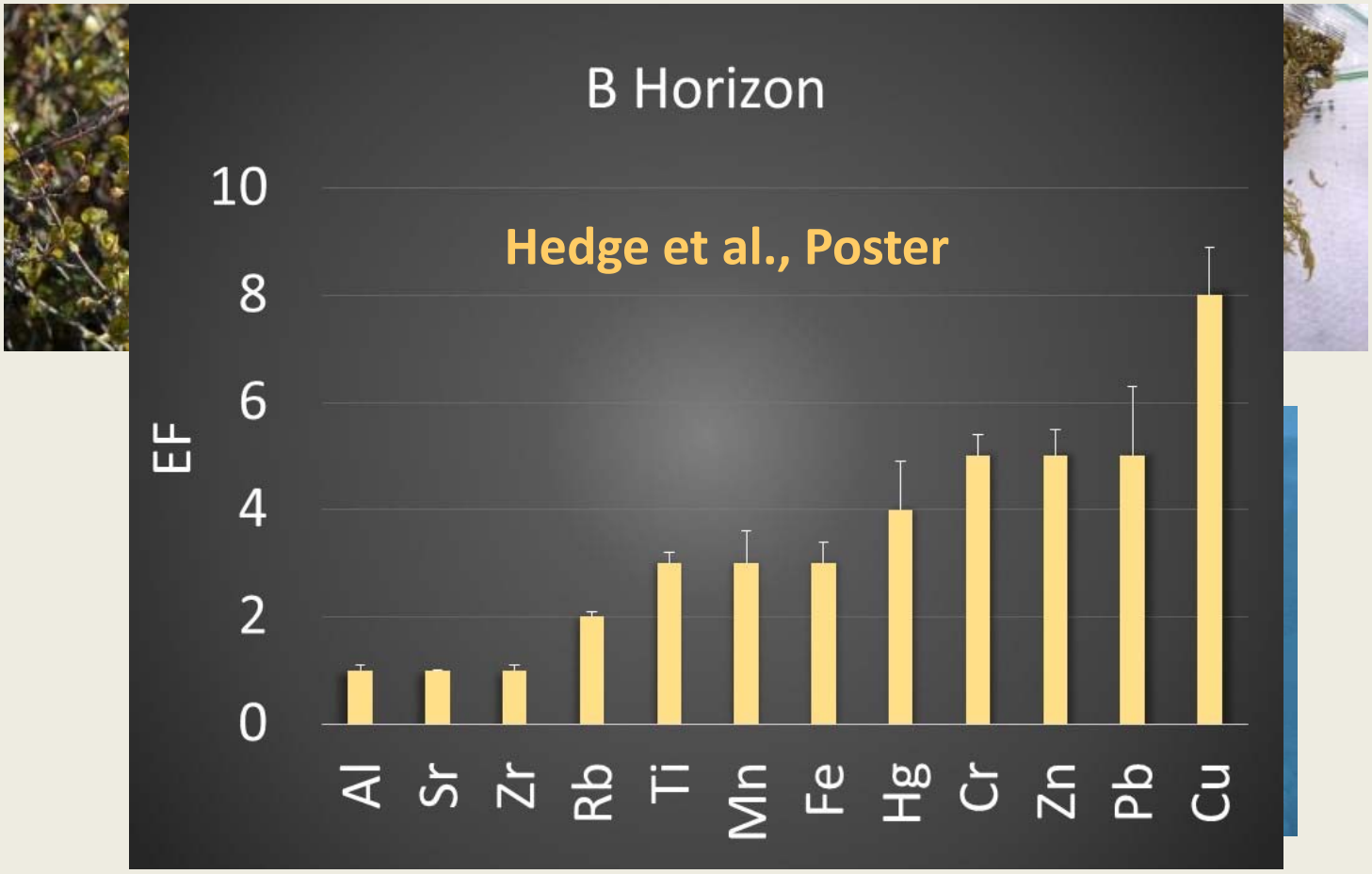


Gaseous $Hg^{0¨}$ / CO_2 / CH_4 / H_2O

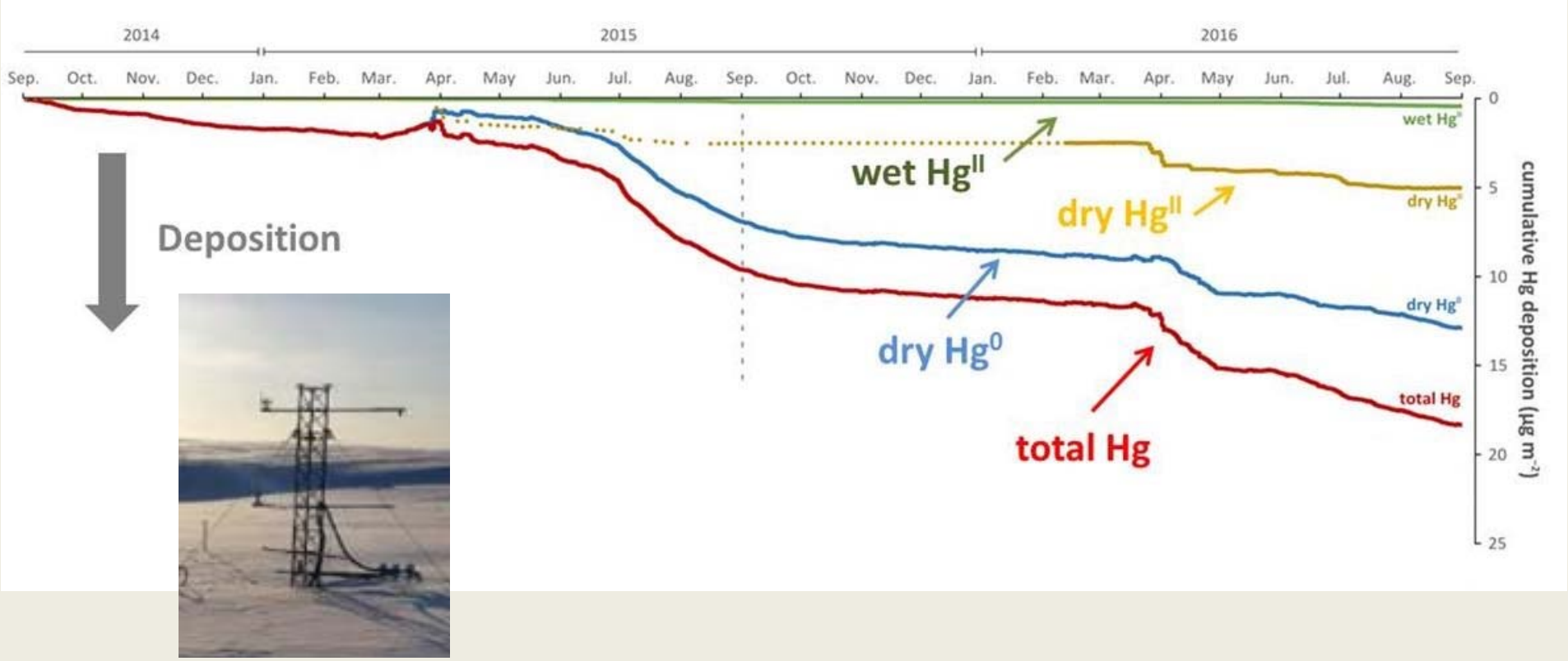
Snowpack, plants, soils

Comprehensive field sampling to develop mass inventories in tundra plants, soils, snowpack (C, N, Hg, Al, Sr, Zr, Rb, Ti, Mn, Fe, Cr, Zn, Pb, Cu)



Atmospheric Hg deposition – mass balance

Cumulative atmosphere-surface Hg exchange – 2 years



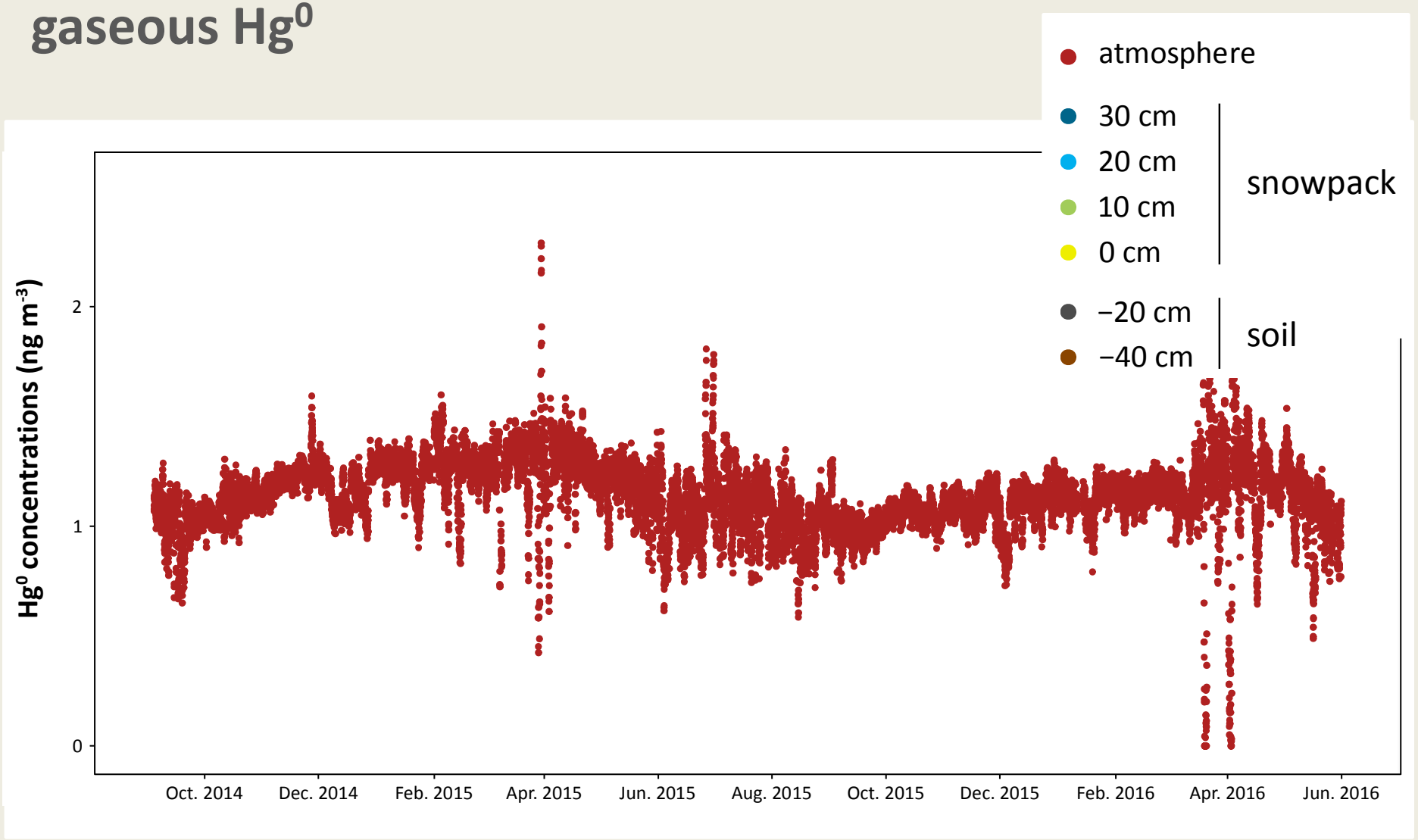
Deposition dominated by gaseous Hg^0 (71%; 6.5±0.7 µg m^{-2} yr^{-1})

Wet deposition (Hg^{II}) was 30 x lower (0.2±0.1 µg m^{-2} yr^{-1})

Dry deposition of Hg^{II} was 2.5 µg m^{-2} yr^{-1} (range 0.8 - 2.8 µg m^{-2} yr^{-1})

Hg^0 in snow and soil

Atmosphere-snow-soil concentration profiles of gaseous Hg^0



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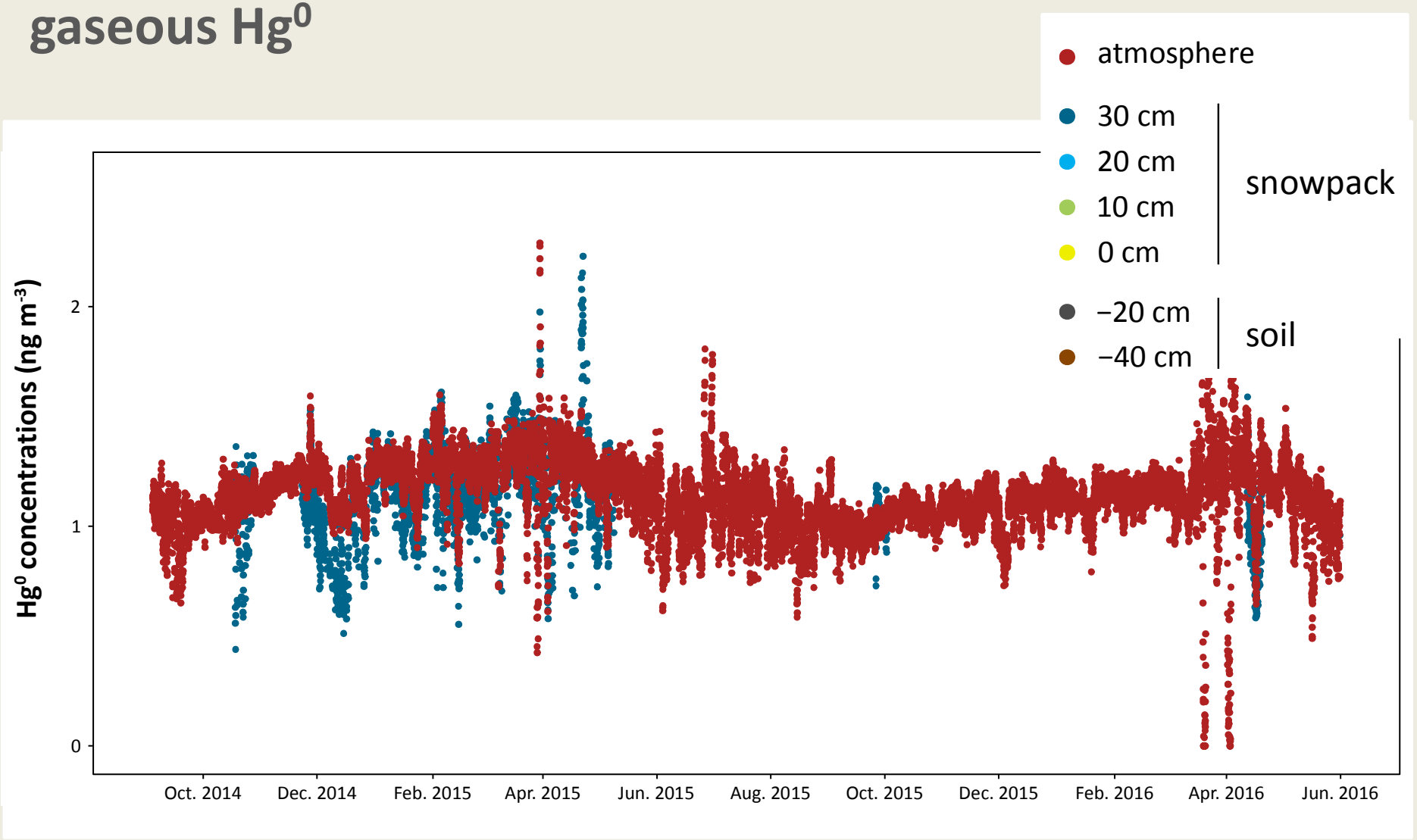

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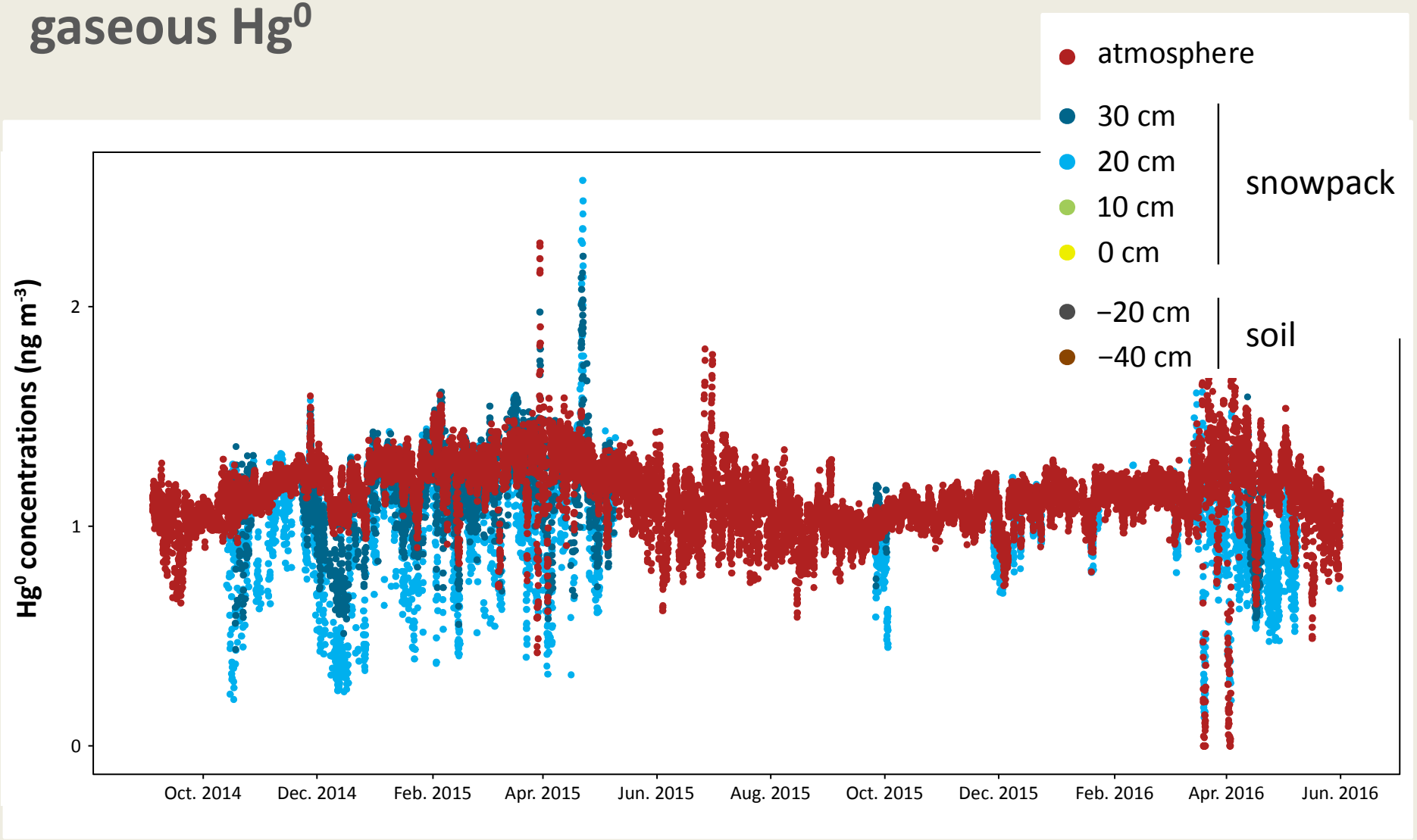

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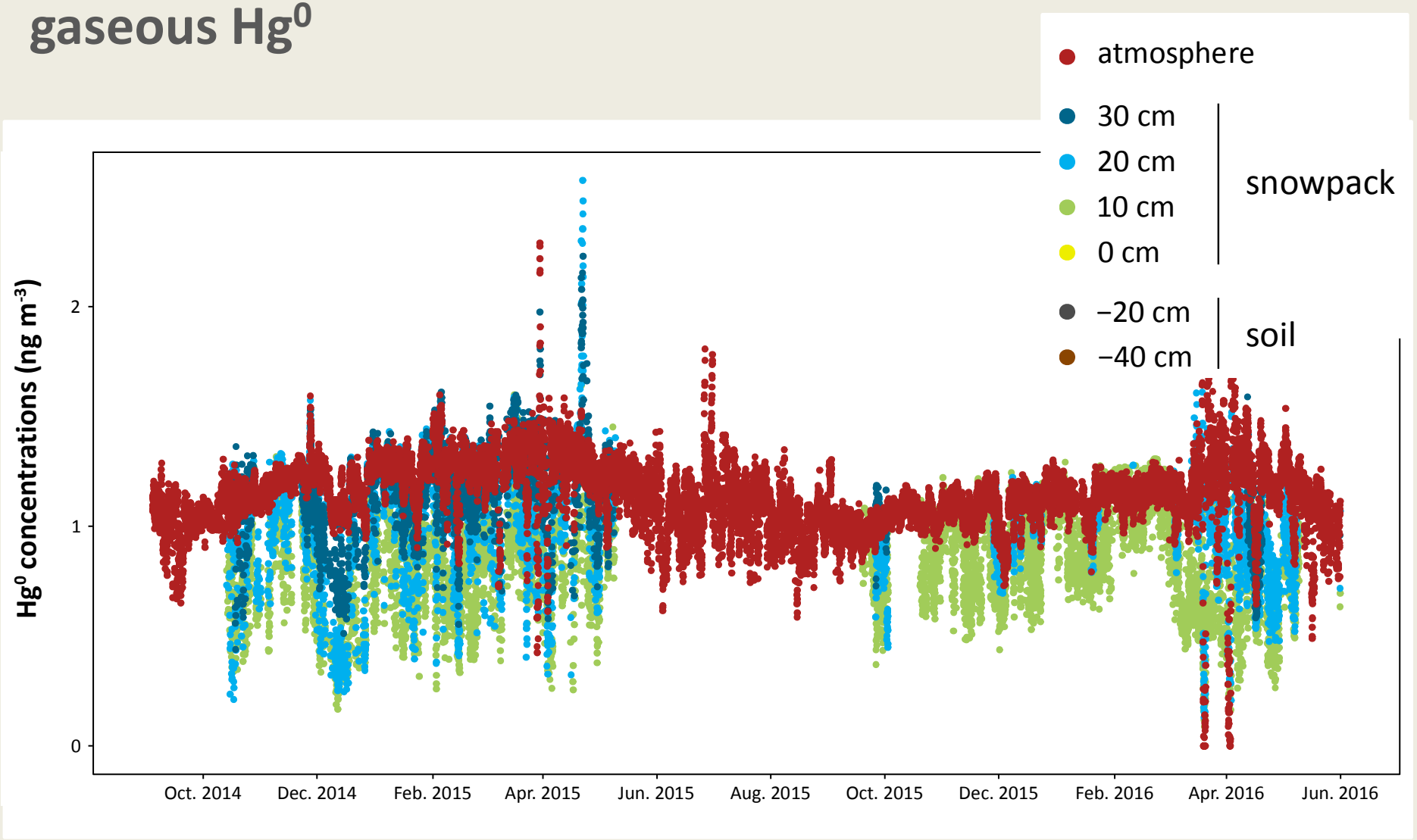

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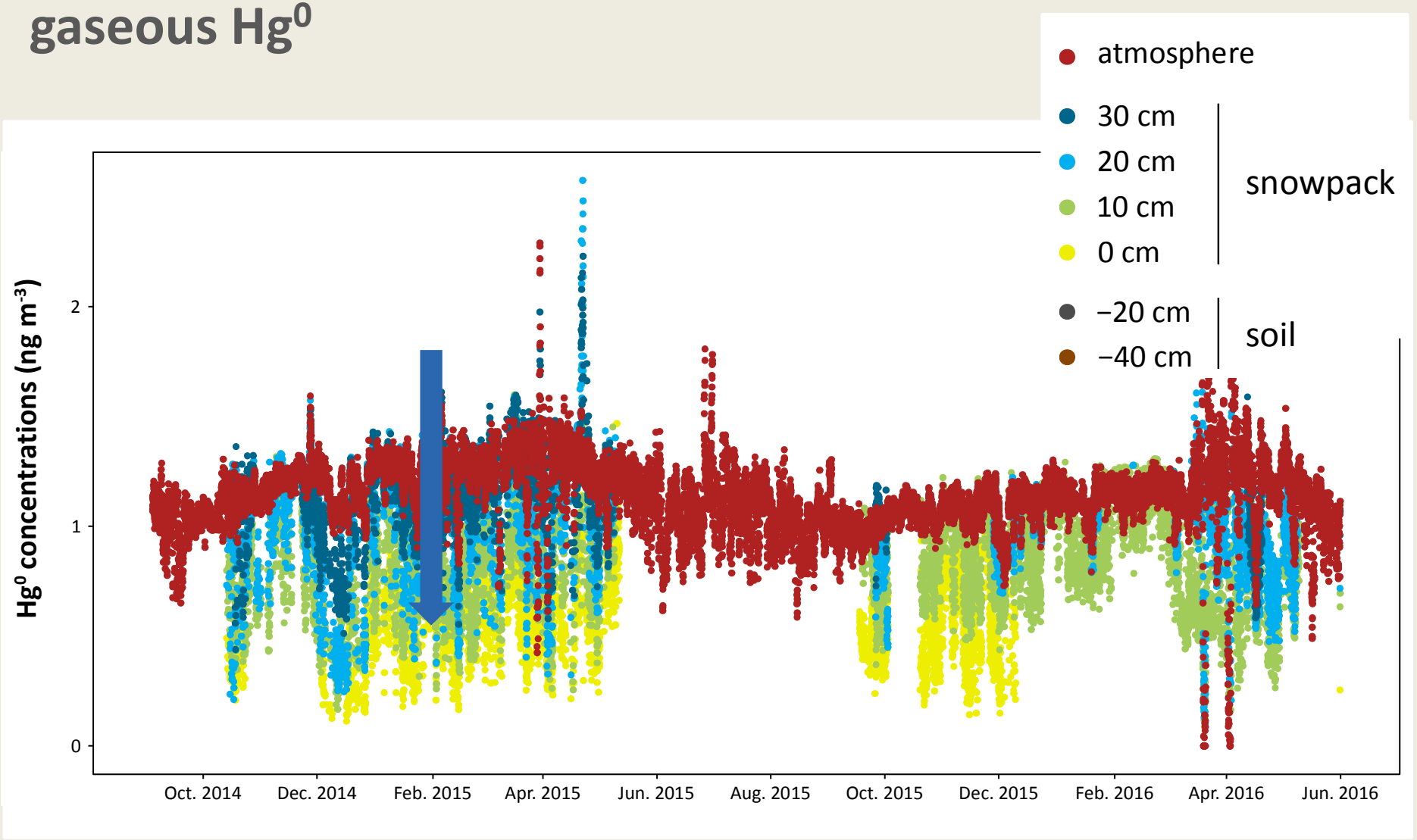

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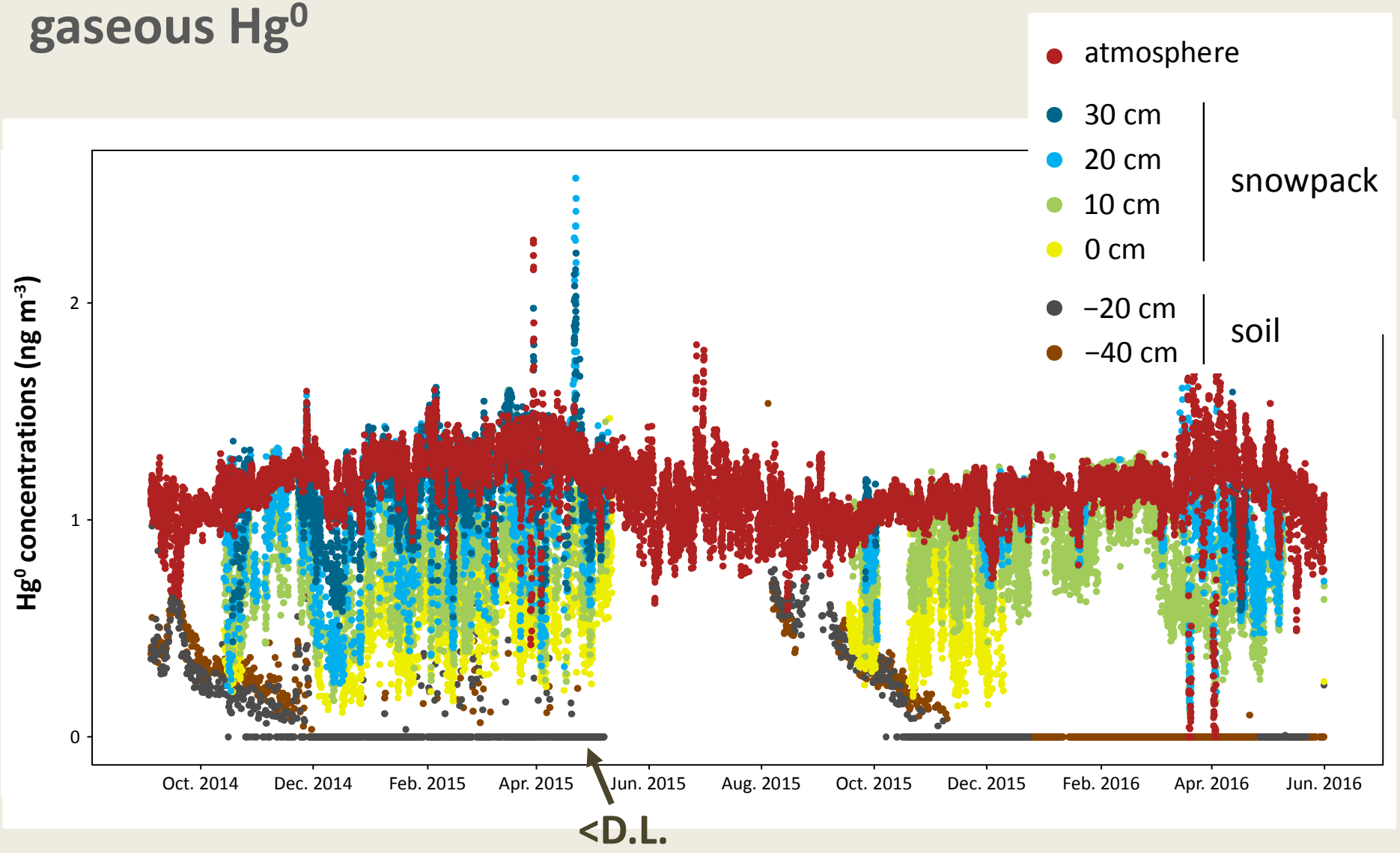

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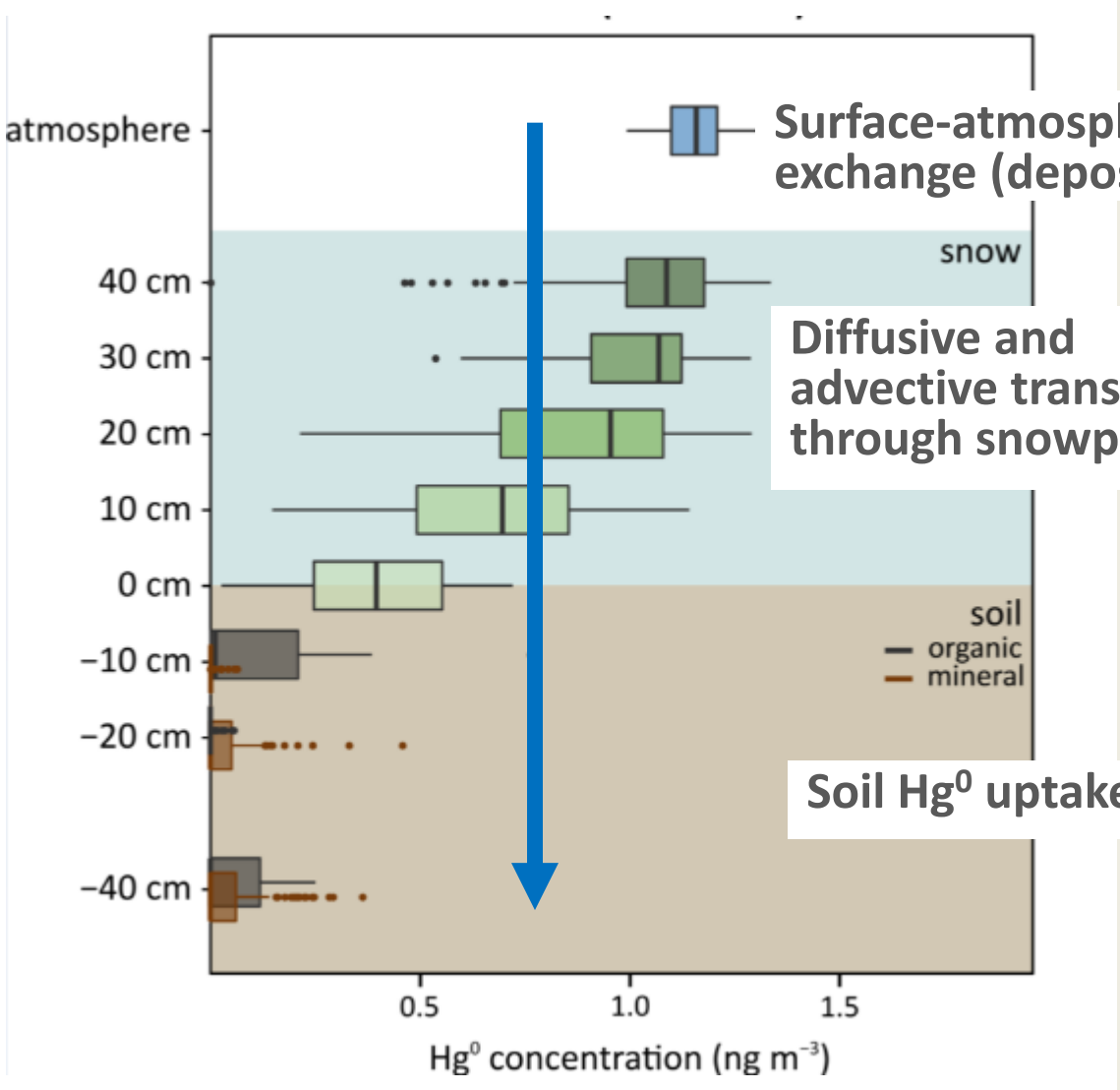
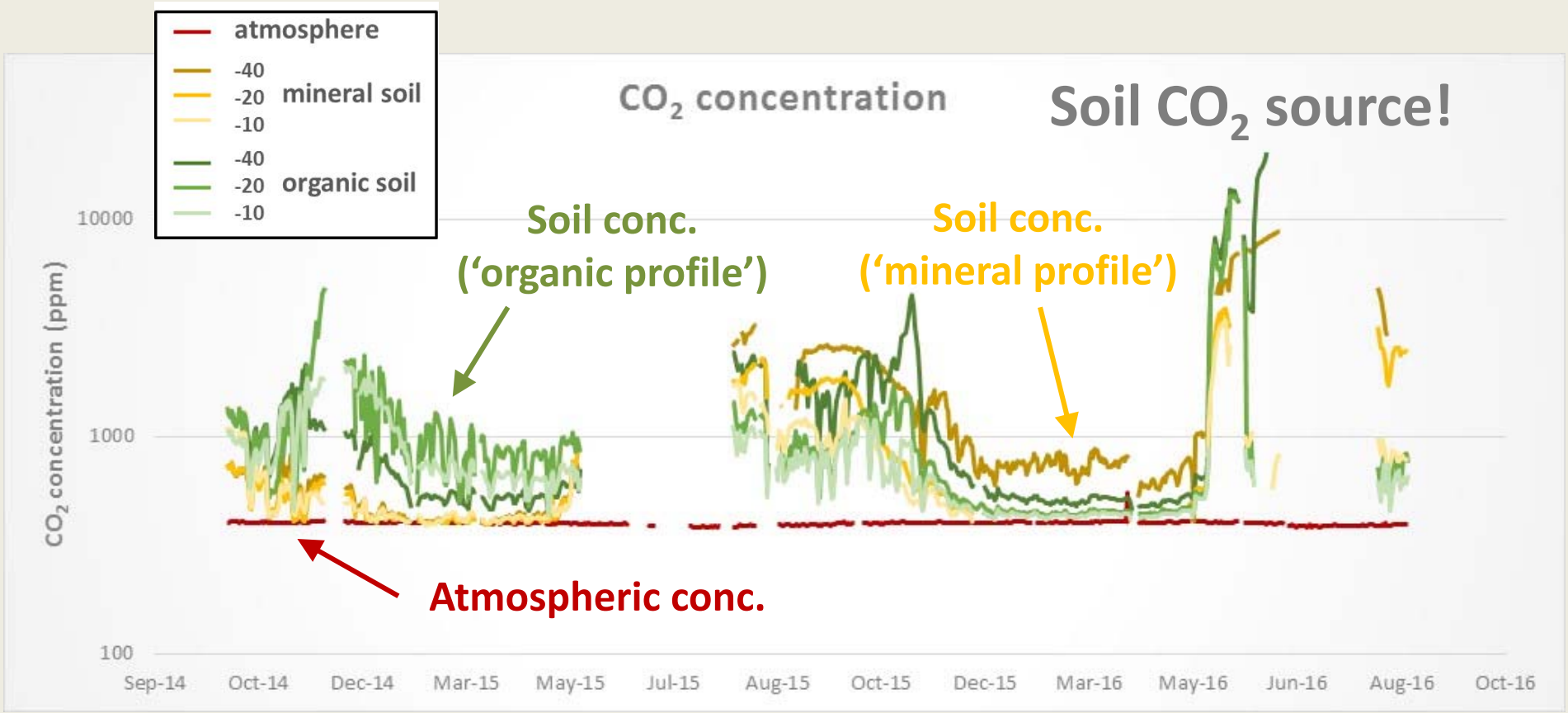


Soil CO_2 concentrations

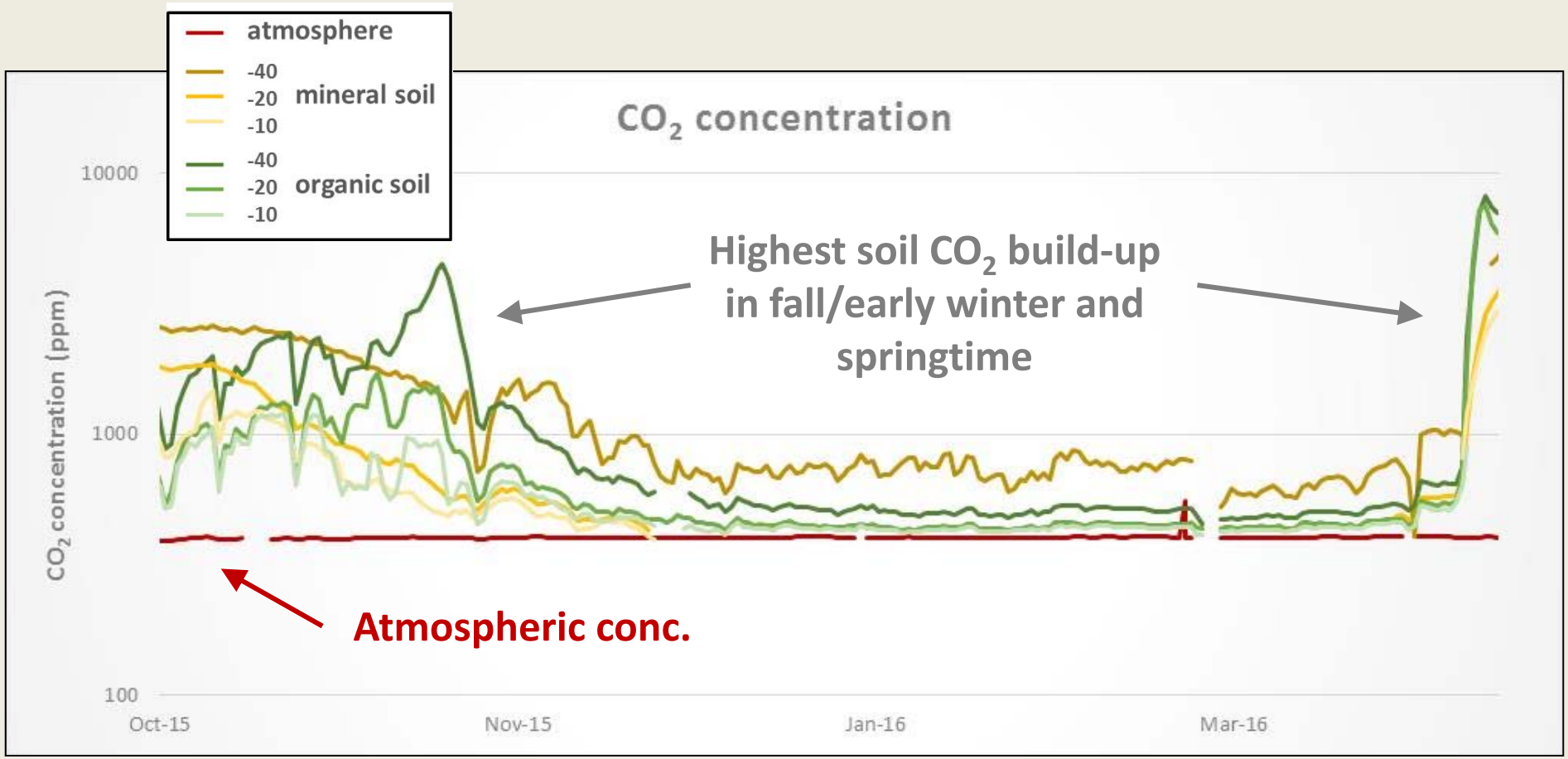
Soil concentrations of CO_2: 2 years



Sept 2014 Sept 2015 Sept 2016

Soil CO_2 concentrations

Soil concentrations of CO_2: wintertime

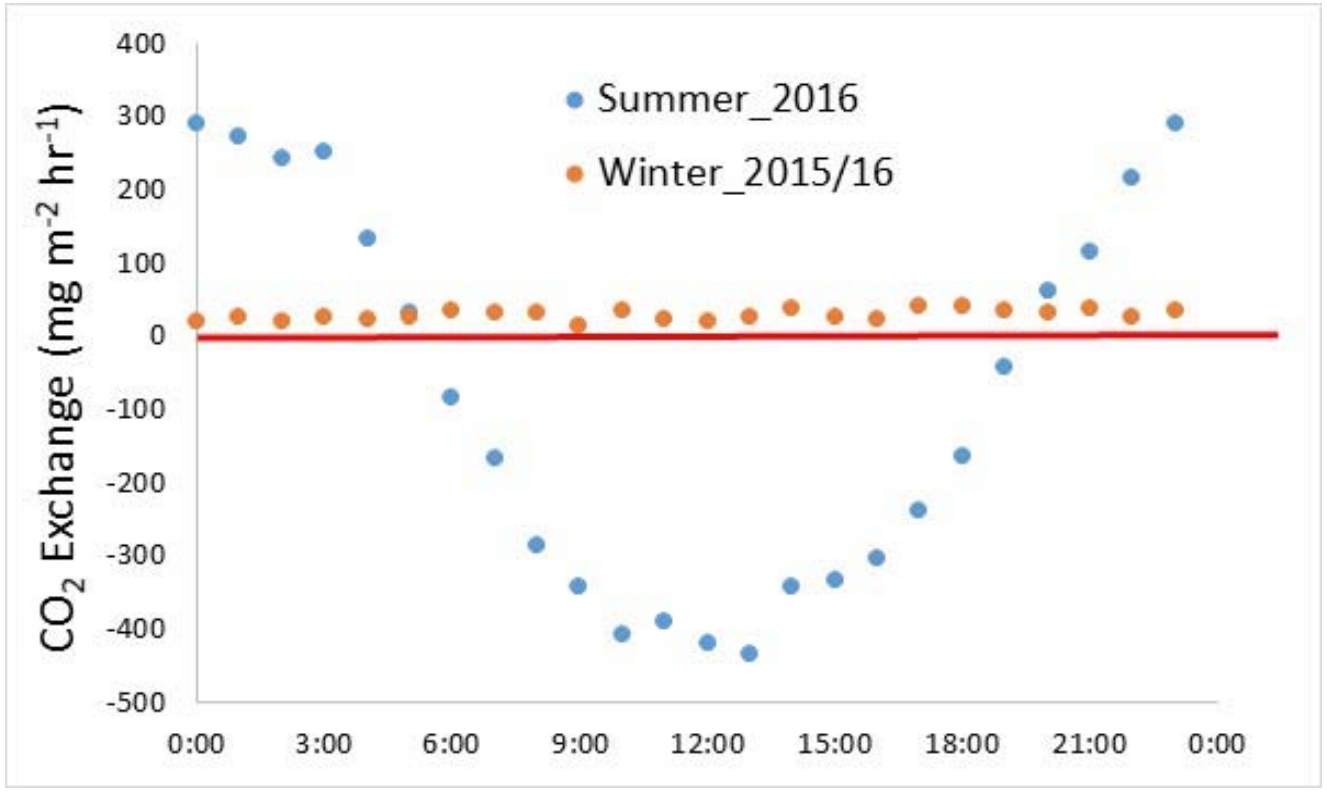


Oct 2015 Jan 2016 Apr 2016

Soil CO_2 concentrations

Soil

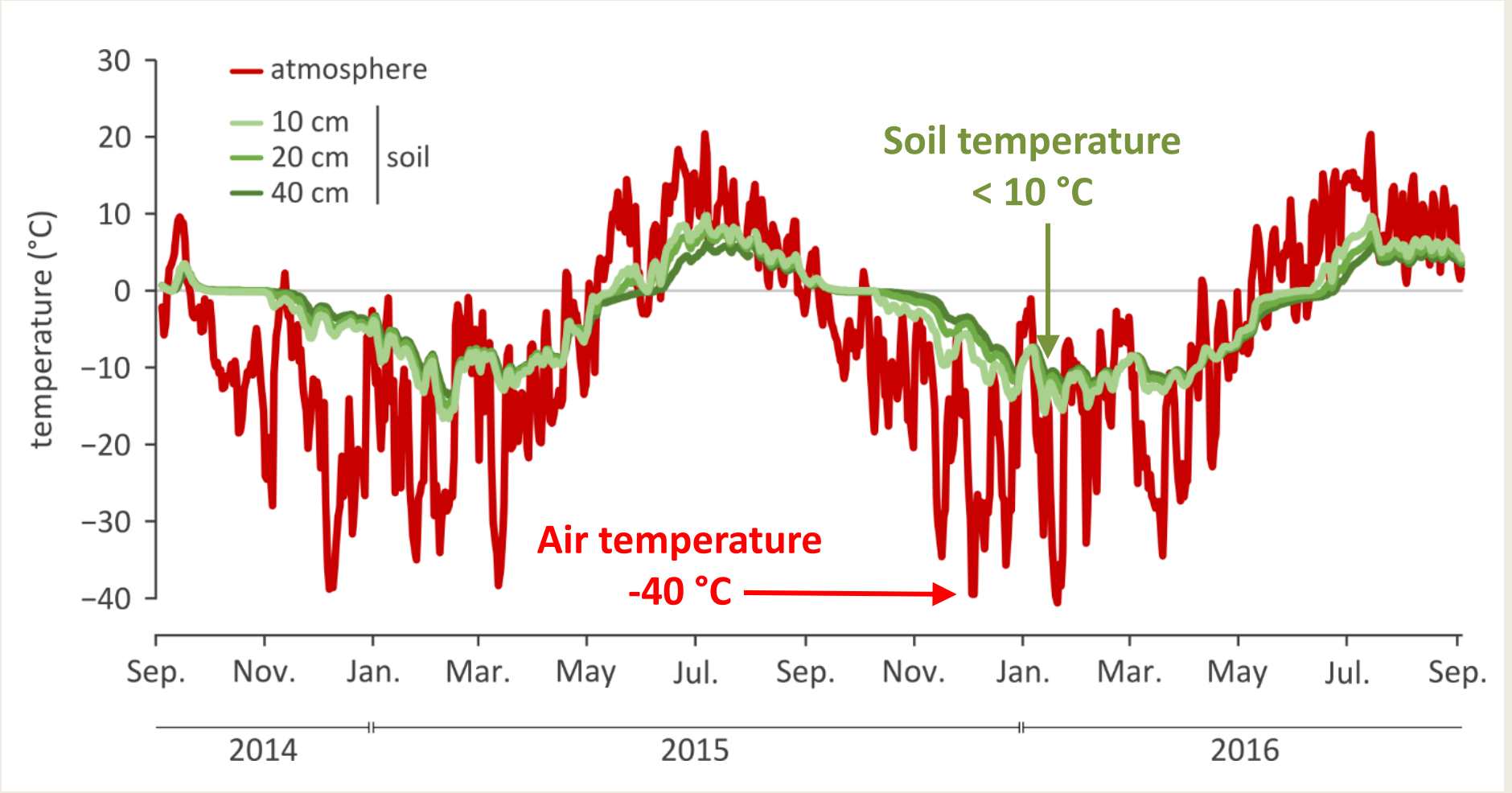
Micrometeorological Fluxes



Oct 2015 **Jan 2016** **Apr 2016**

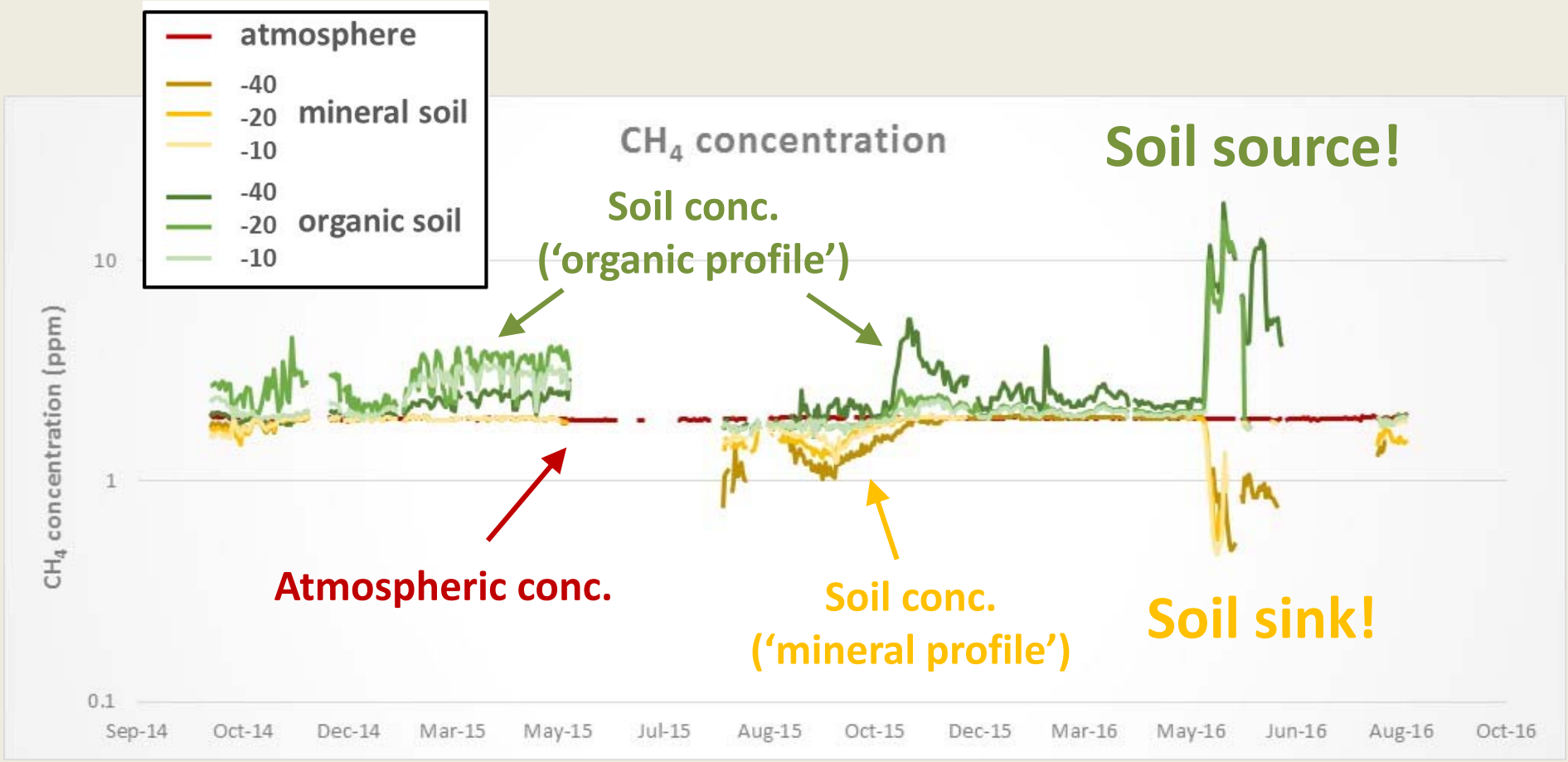
Soil Temperatures

Air and soil temperatures



Soil CH_4 concentrations

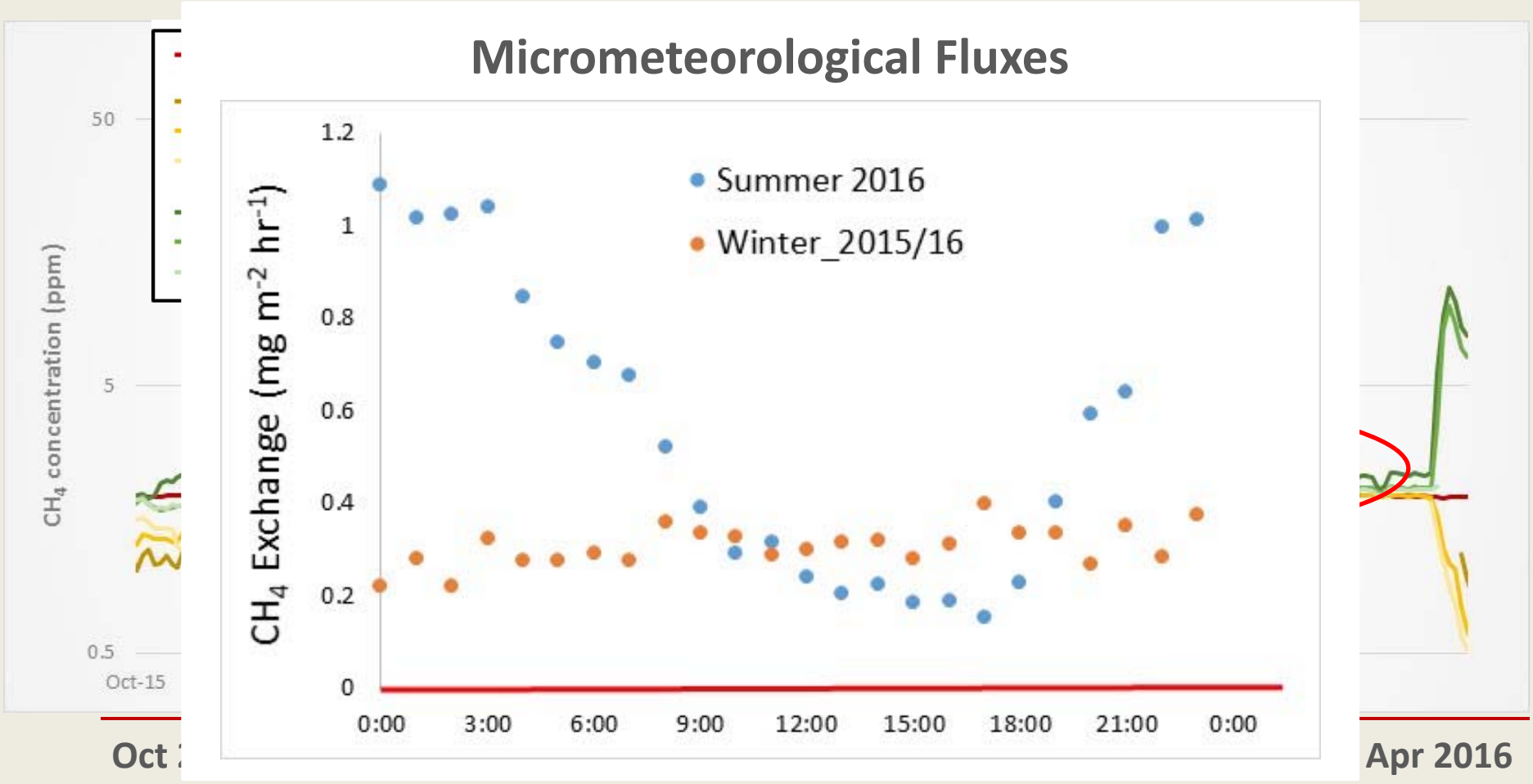
Soil concentrations of CH_4: 2 years



Sept 2014 Sept 2015 Sept 2016

Soil CH_4 concentrations

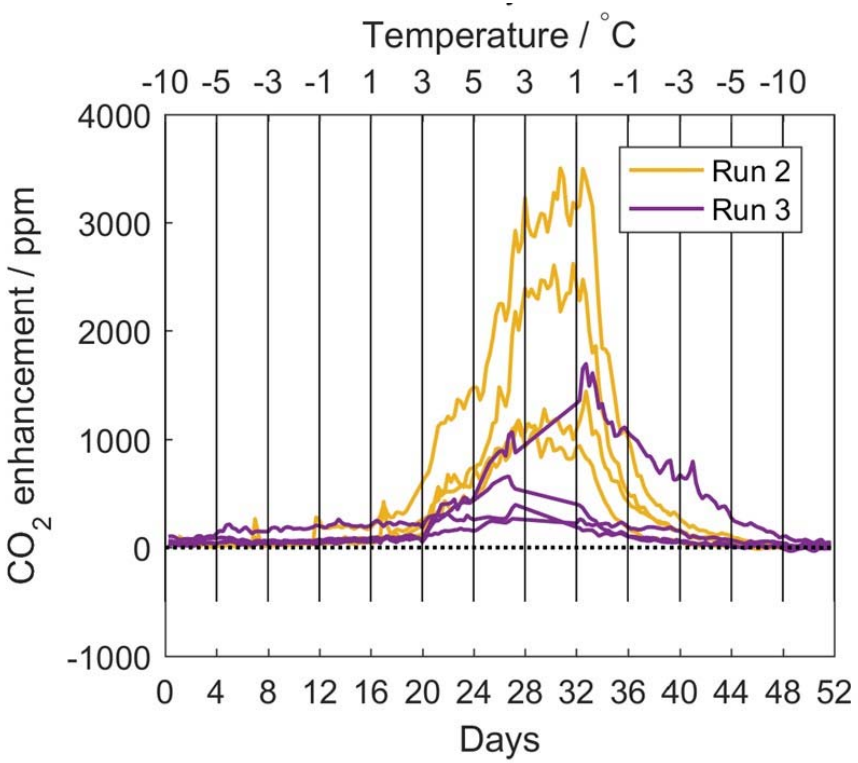
Soil concentrations of CH_4: wintertime



Soil CH_4 concentrations

Soil concentrations of CH_4: wintertime

Poster D. Howard: CO_2 and CH_4 evolution under controlled freeze/thaw cycling



Conclusions

Soil CO_2 production in Toolik soils occurs throughout the year – incl. in mid-winter

For CH_4, sinks and sources are in close proximity, and show different temperature sensitivities

Soil diffusivity strongly determines concentration profiles (i.e., during freezing and thawing)

Conclusions

Atmosphere-snow-soil gas profiles reveal temporal and spatial information on sinks and sources

Surface-atmosphere flux measurements are consistent with concentration profiles

Two year deposition mass balance for Hg shows that gaseous Hg^0 dominates (71%) as a Hg source in the tundra

Thank you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INSTITUTE OF ARCTIC BIOLOGY
UNIVERSITY OF ALASKA FAIRBANKS


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Desert Research Institute


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