Understanding COS fluxes in a boreal forest: towards COS-based GPP estimates.

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Carbonyl sulfide (COS) as tracer for photosynthetic Carbon uptake

\[ F_{\text{COS}} = \frac{GPP}{[\text{CO}_2]} \frac{[\text{COS}]}{V_{\text{COS/CO}_2}} \]

\[ \text{NEE} = \text{GPP} - \text{Re} \]

NEE = Net Ecosystem Exchange
GPP = Gross Primary Production
Re = Respiration
Carbonyl sulfide (COS) as tracer for photosynthetic Carbon uptake

\[ F_{COS} = \frac{GPP \left[ \frac{COS}{CO_2} \right]}{V_{COS/CO_2}} \]

Environmental drivers of COS fluxes?

\[ \text{NEE} = \text{GPP} - \text{Re} \]

CO\(_2\)

COS

Soil?

NEE = Net Ecosystem Exchange
GPP = Gross Primary Production
Re = Respiration
InGOS measurement campaign: Hyytiälä, Finland
Measurement setup

COS and CO$_2$ measurements:
• Eddy-covariance (23 m)
• Profile: 0.5, 4, 14, 23, 125 m
• Soil chamber fluxes

• Meteorological variables, Soil temp. and humidity, $^{222}$Radon, etc.
Aerodyne QCLS for COS, CO$_2$, CO and H$_2$O measurements

**Precision** (2 minute meas.): between 3.4 – 4.1 ppt COS, 0.03 – 0.04 ppm CO$_2$.

**Reproducibility**: 2.1 ppt COS, 0.1 ppm CO$_2$. 

10 Hz: Eddy-cov.

1 Hz: Profile + soil chamber
Ecosystem COS and CO$_2$ flux at 23 m
Ecosystem COS and CO$_2$ flux at 23 m
Profile measurements

- CO₂ [ppm]
  - 370
  - 390
  - 410
  - 430

- COS [ppt]
  - 250
  - 350
  - 450

- Height [m]
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60
  - 70
  - 80
  - 90
  - 100
  - 110
  - 120

- Tree:
  - 19 m
  - 23 m
  - 14 m
  - 4 m
  - 0.5 m

- Measurements:
  - 125 m
  - 12 jul 10:00
Flux-gradient method

27-19 m CO₂ flux

\[ F_{CO_2} = -K \frac{\Delta C_{CO_2}}{\Delta Z} \rho \]

\[ K = \frac{u_* k (z - d)}{\varphi_m} \]
Flux-gradient method

27-19 m COS flux

\[ F_{\cos} = -K \frac{\Delta C_{\cos}}{\Delta Z} \rho \]

\[ K = \frac{u_* k (z - d)}{\varphi_m} \]
Radon-tracer method

\[ F_{COS} = F_{Rn} \frac{\Delta C_{COS}}{\Delta C_{Rn}} \]

\[ F_{Rn} = 2.8 \text{ mBq m}^{-2} \text{ s}^{-1} \]

Manohar et al., 2013
Radon-tracer method

\[ F_{COS} = F_{Rn} \frac{\Delta C_{COS}}{\Delta C_{Rn}}, \quad F_{Rn} = 2.8 \text{ mBq m}^{-2} \text{ s}^{-1} \]

- COS / CO\textsubscript{2} concentration
- Radon concentration
- COS / CO\textsubscript{2} vs radon correlation
- COS / CO\textsubscript{2} eddy covariance flux
Radon-tracer method

\[ F_{COS} = F_{Rn} \frac{\Delta C_{COS}}{\Delta C_{Rn}}, \quad F_{Rn} = 2.8 \text{ mBq m}^{-2} \text{ s}^{-1} \]

Radon flux vs EC flux
Conclusion

- Ongoing field campaign on COS fluxes in Finland.
- Radon-tracer method for nighttime COS and CO$_2$ fluxes is promising.
- Flux-gradient method for COS fluxes requires further investigation.

Next...
- Compare different flux measurement techniques (Radon tracer method, flux-profile, soil, eddy covariance).
- Derive COS-based GPP estimates for the Hyytiälä site.