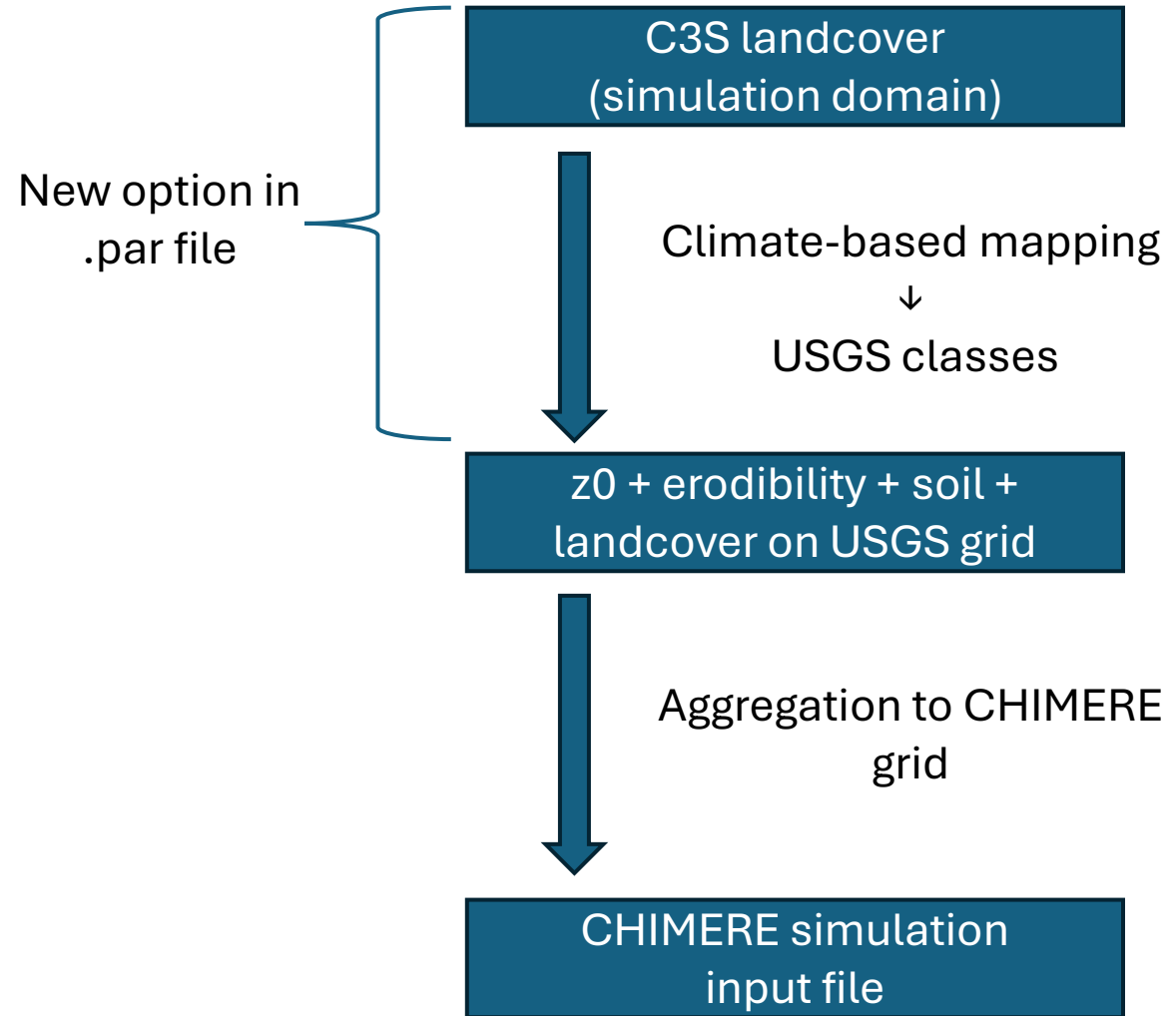


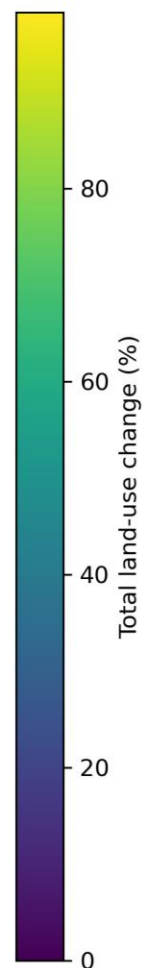
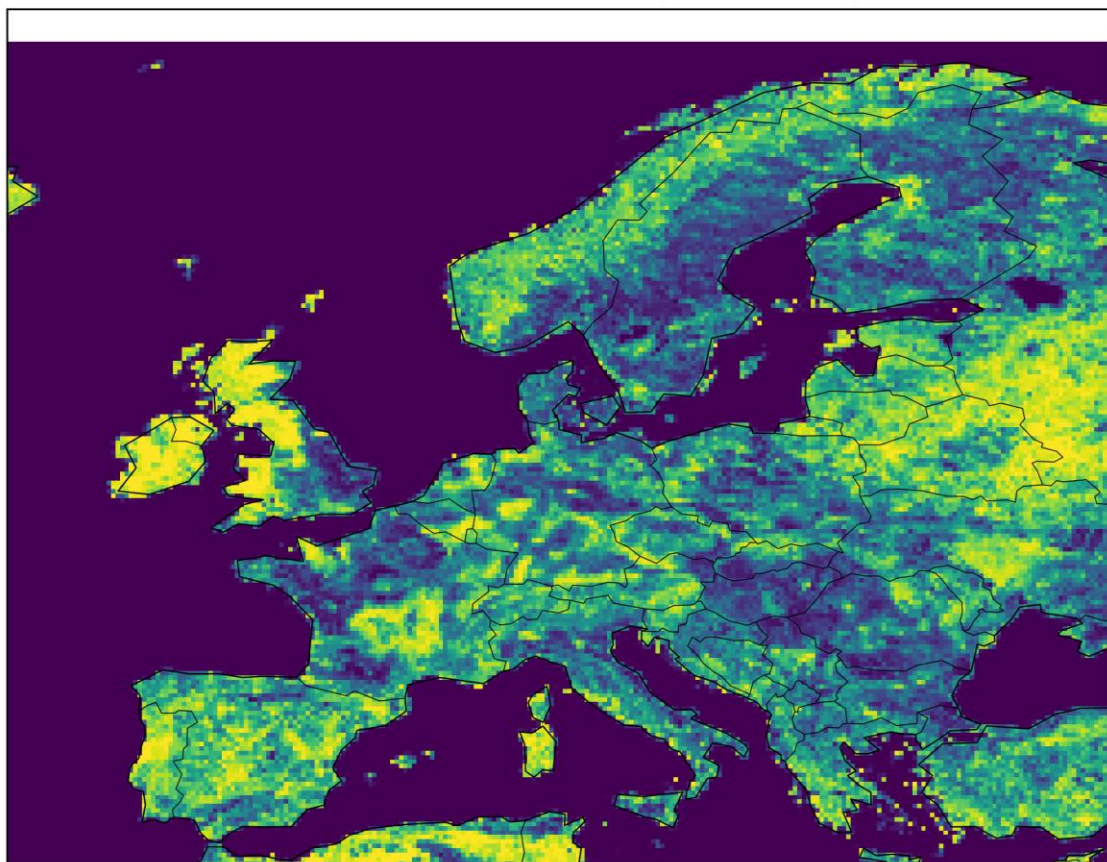
Surface and boundary layer sensitivities in CHIMERE under updated CAMS land-use specifications

Landcover update : USGS to C3S 2022

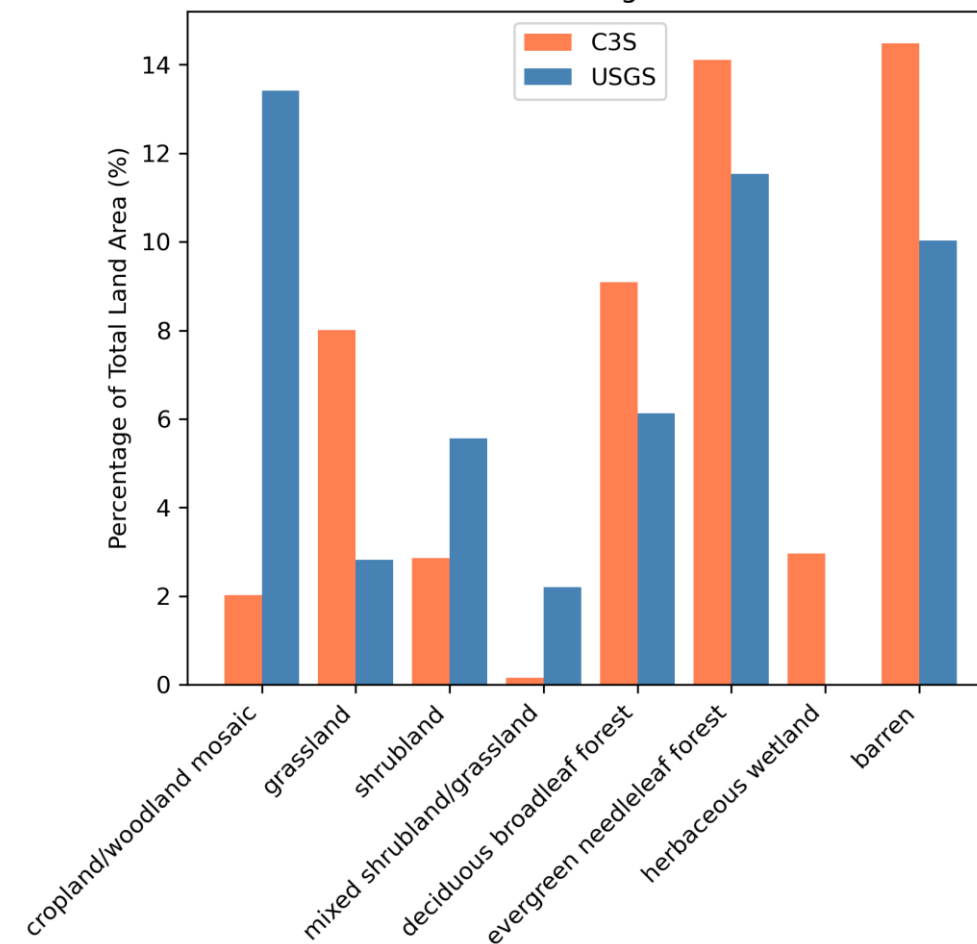


Landcover update : USGS to C3S 2022

Total Land Cover Difference (C3S vs USGS)



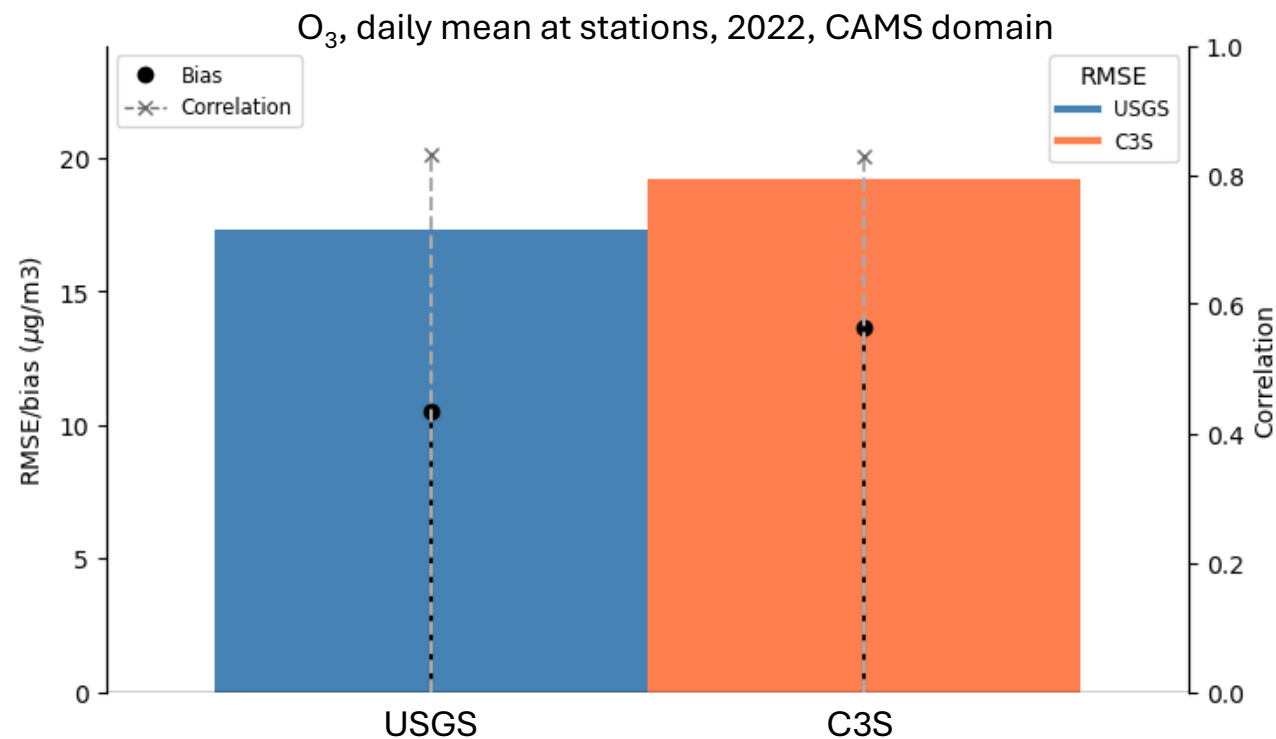
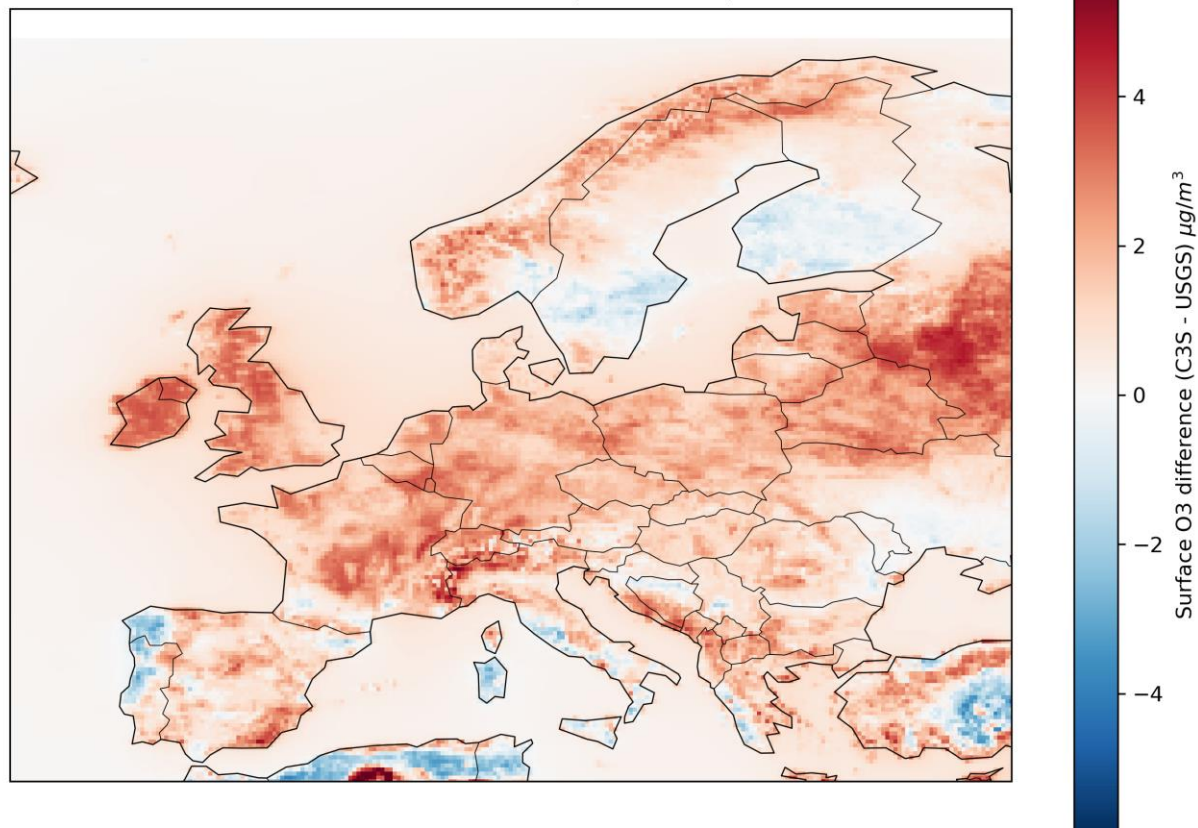
Main Land cover changes: C3S vs USGS



- Strong spatial variability (Eastern & Mediterranean Europe, UK and Scandinavia)
- Less mixed classes

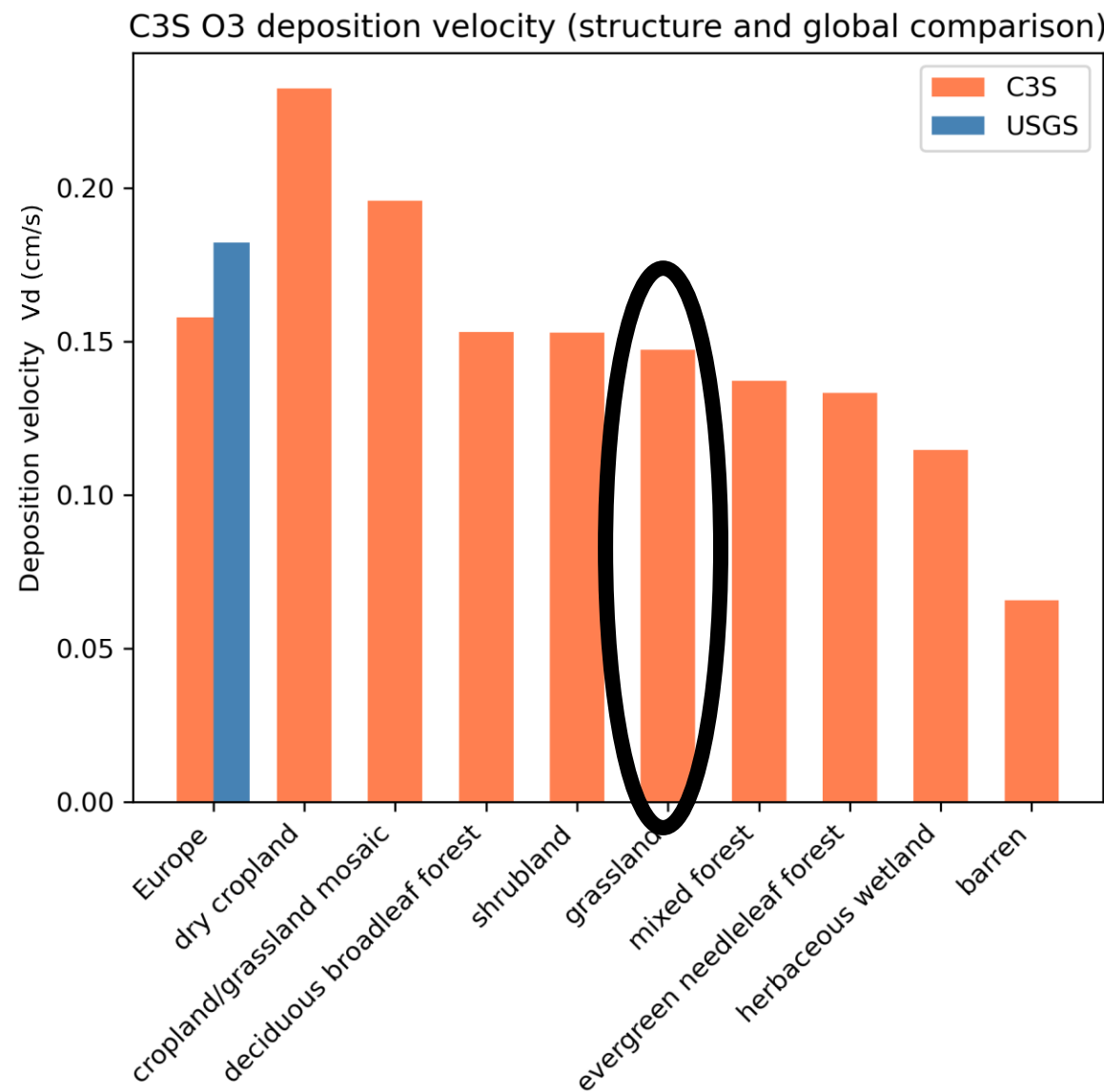
USGS and C3S O₃ performances

Surface O₃ difference (C3S - USGS)

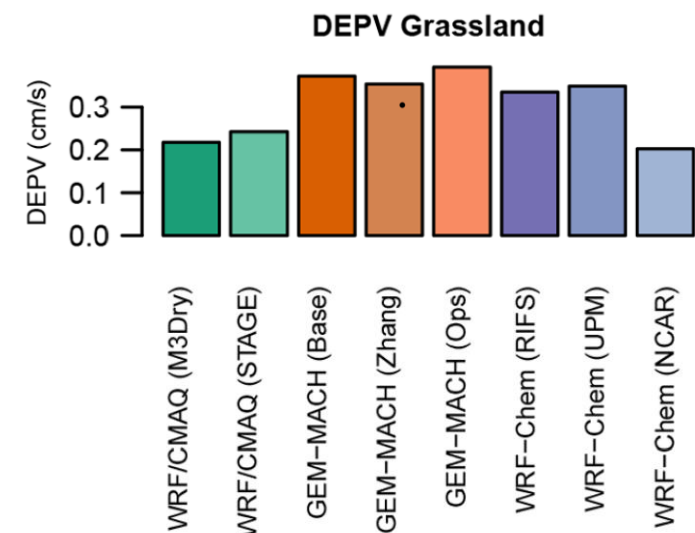


- New landcover leads to overall increase of surface O₃
 - RMSE increases ($\sim +2 \mu\text{g}/\text{m}^3$) and Bias increases ($\sim +3 \mu\text{g}/\text{m}^3$) at stations
- Update CHIMERE parameters to fit C3S landcover

USGS and C3S deposition velocities v_d for O_3



- Grassland has deposition velocities much lower than croplands and similar to forests
- Low compared to literature

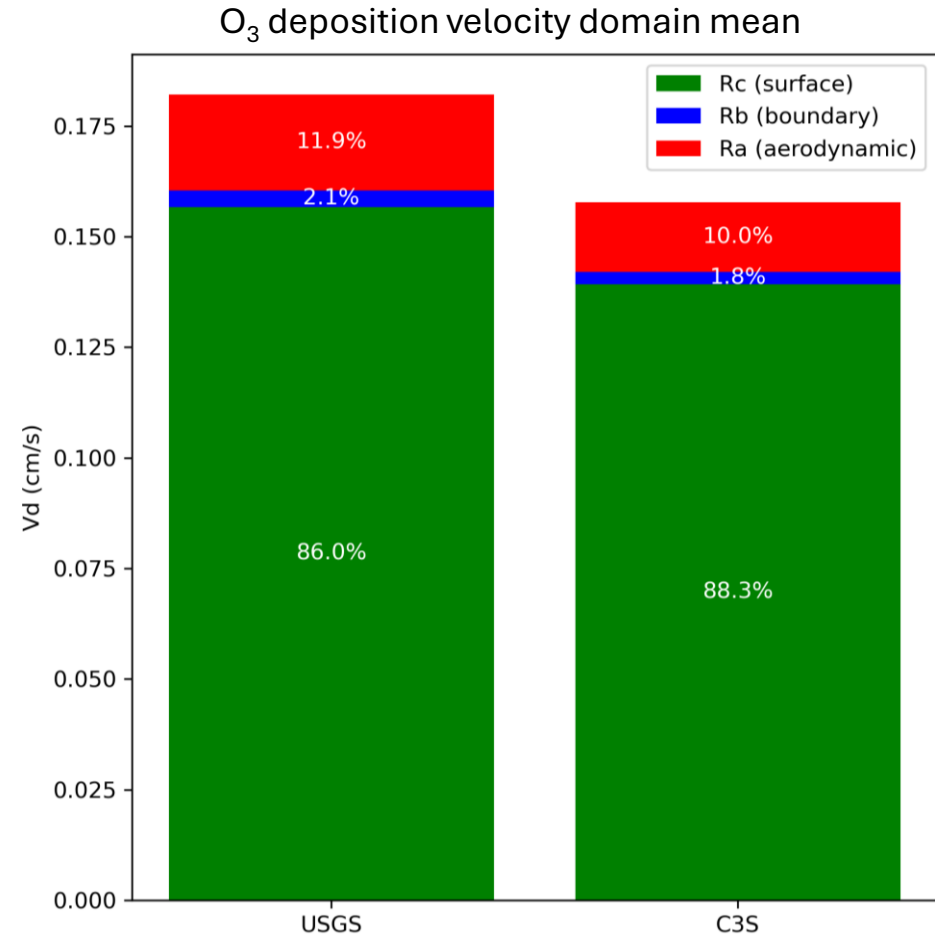
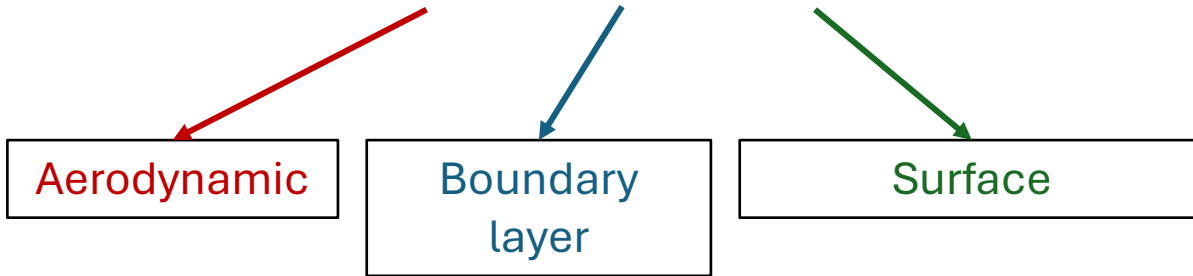


AQMEII4
Hogrefe et al., 2025

Landcover controls on O₃ deposition velocity

Deposition
velocity

$$v_d = \frac{1}{R_a + R_b + R_c}$$

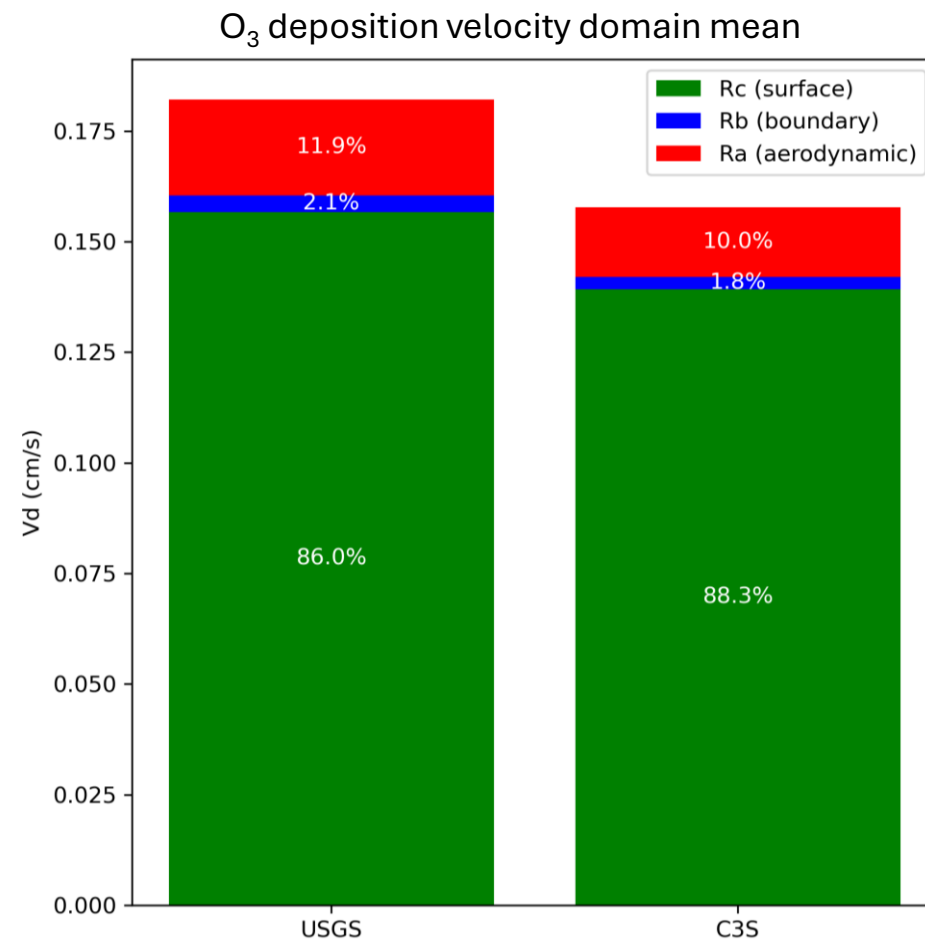
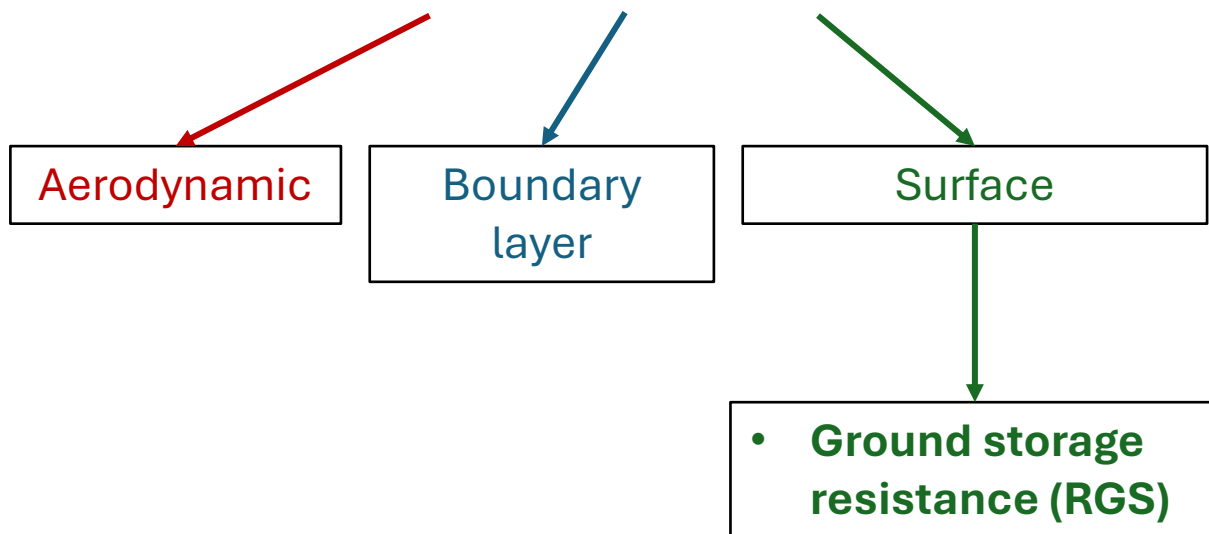


- Surface resistance (R_c) dominates strongly
- Focus on surface parameters

Landcover controls on O₃ deposition velocity

Deposition
velocity

$$v_d = \frac{1}{R_a + R_b + R_c}$$

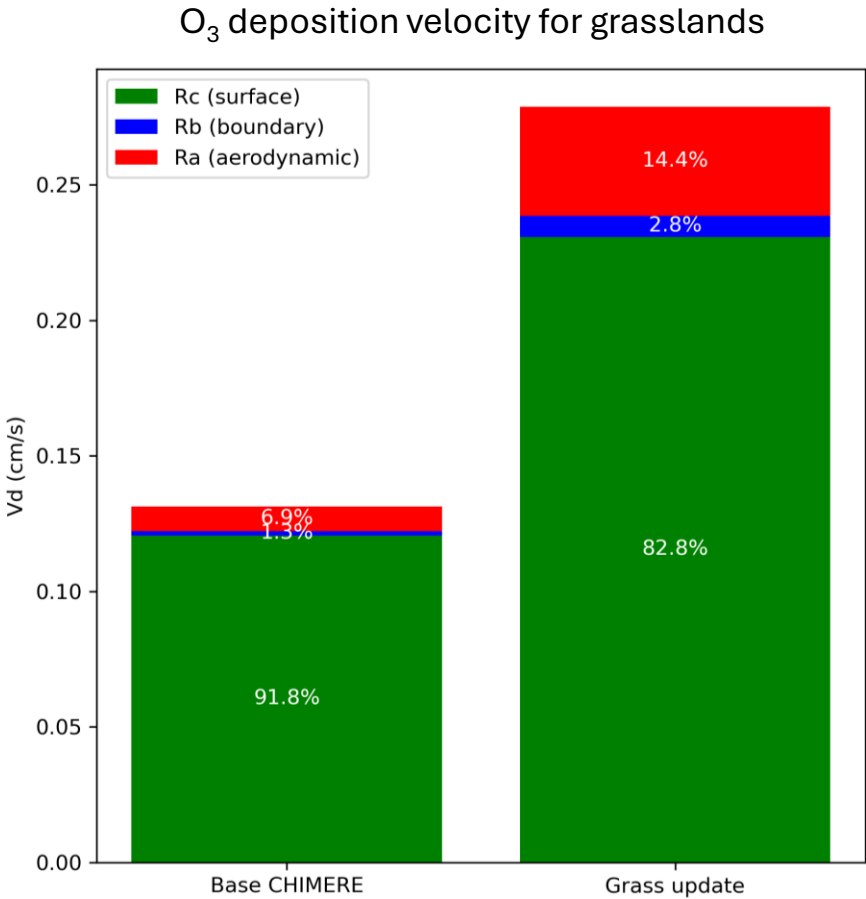


- Surface resistance (R_c) dominates strongly
- Focus on surface parameters

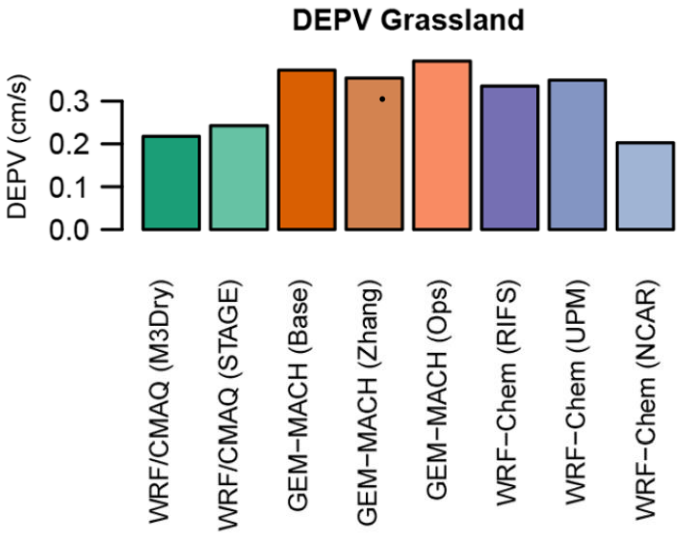
C3S simulation with RGS O₃ update for grassland

- Update RGS according to Clifton et al., 2020

Grasslands	Base	➔	Update
<i>RGS (s/m)</i>	1000		200



- $v_d + 0.14$ cm/s (100%)
- Strong sensitivity to RGS and R_c
- More consistent with the literature



AQMEII4
Hogrefe et al., 2025

Complete RGS O₃ update (Clifton et al., 2020)

	Moorland	Grass	Wetlands
<i>RGS (s.m⁻¹)</i>	400	1000	2000



	Moorland	Grassland	Wetlands
<i>RGS (s.m⁻¹)</i>	200	200	500

➤ Update all RGS :
700 to **330 s/m** domain mean

Tundra	Desert	Ice	Urban
400	2000	2000	400

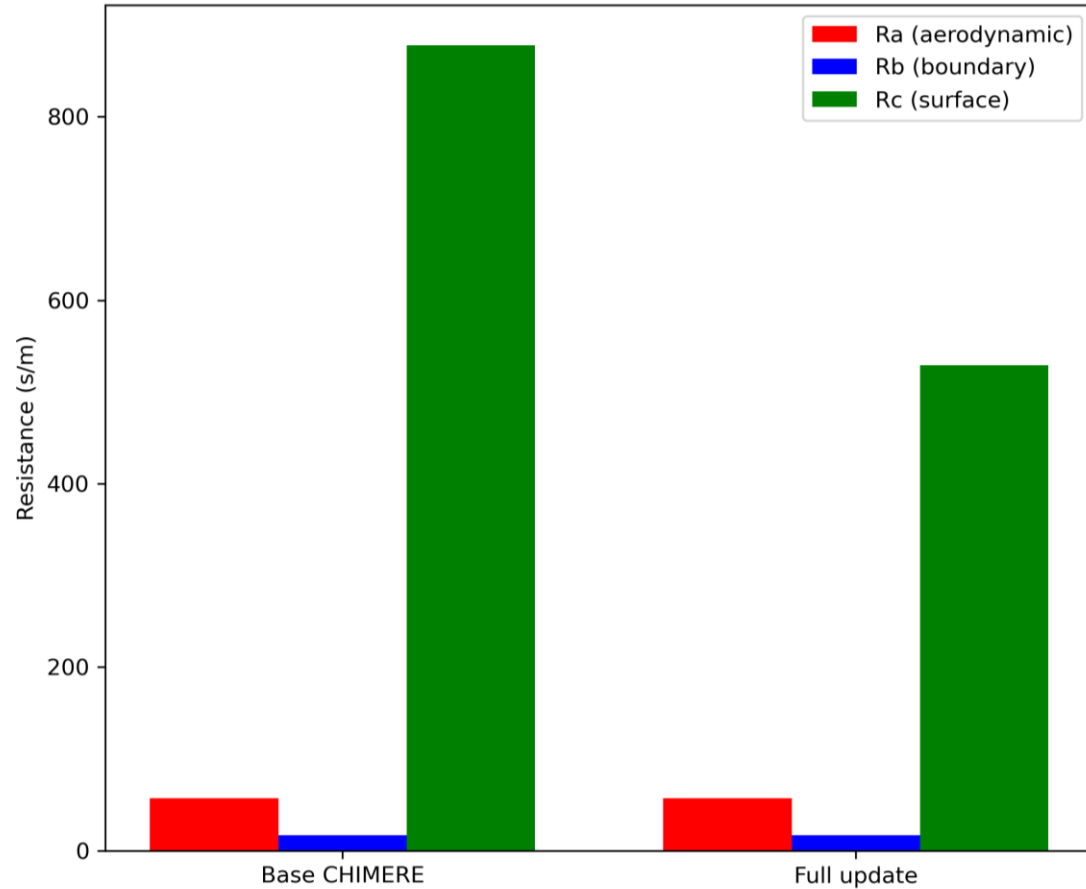


Tundra	Desert	Ice	Urban
200	500	7000	200

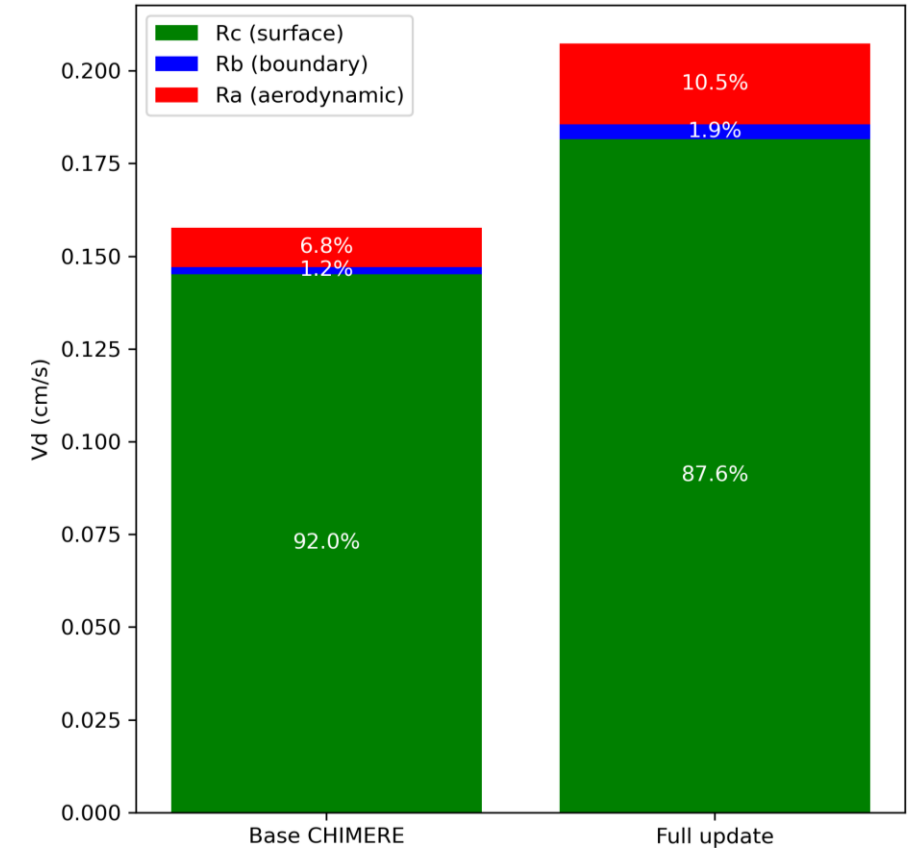
C3S simulation with complete RGS O₃ update

- RGS decrease ~ R_c decrease

O₃ deposition resistances



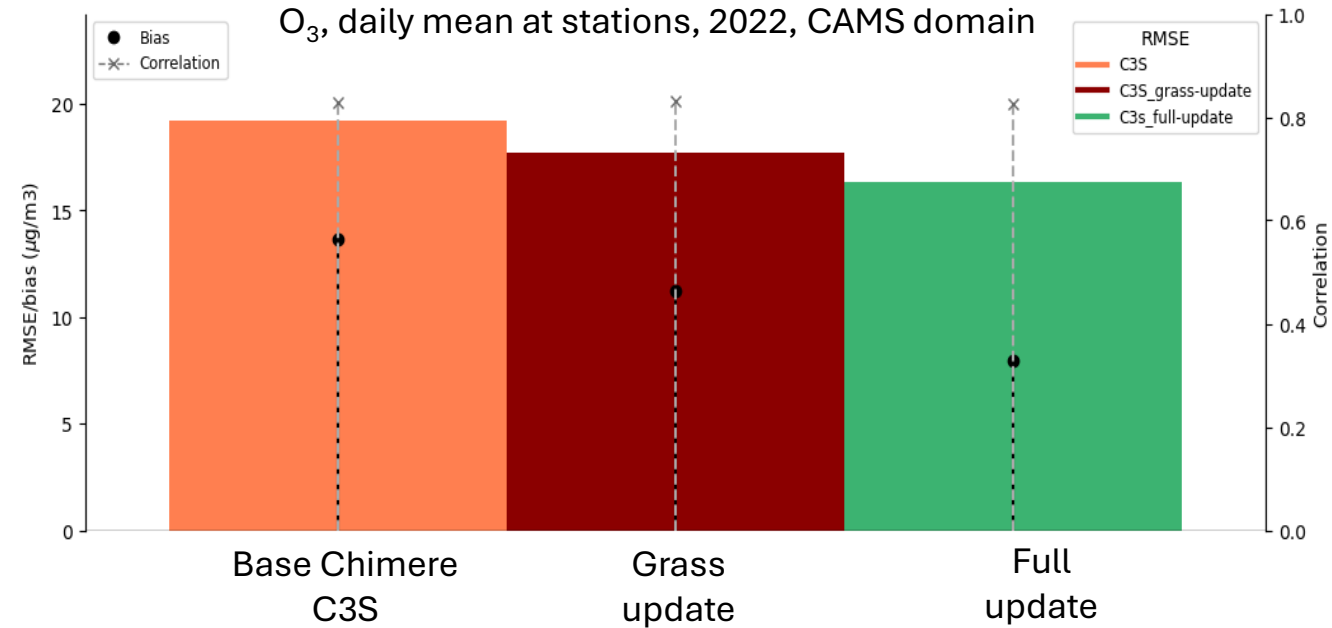
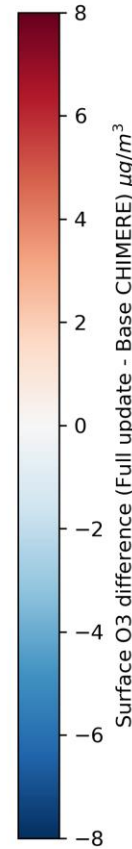
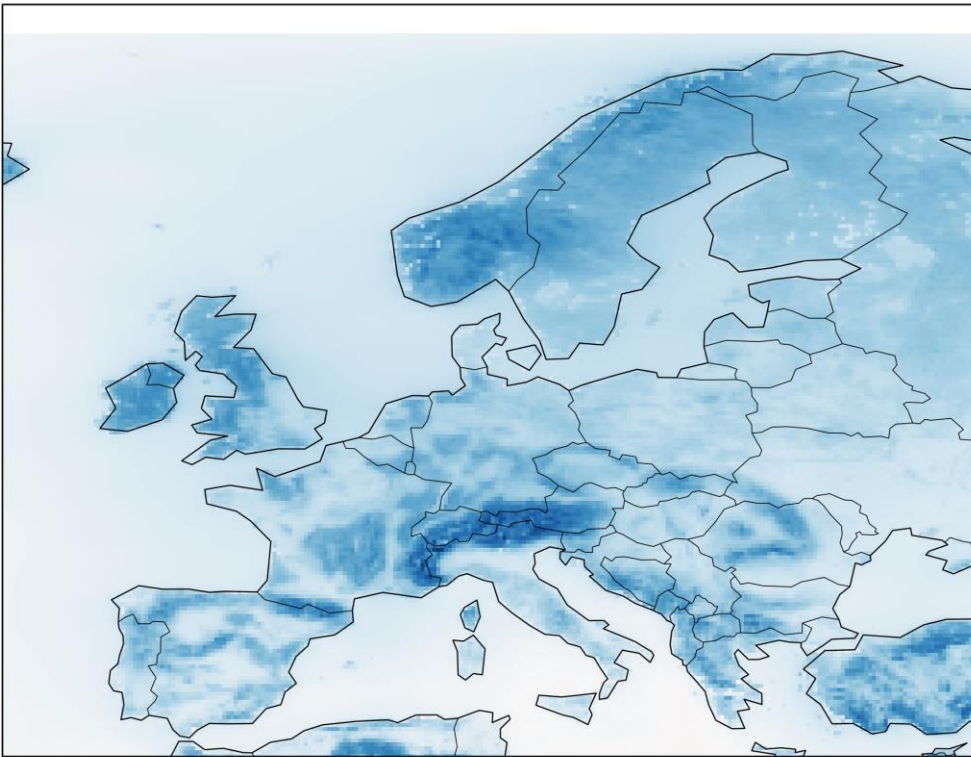
O₃ deposition velocity domain mean



- $v_d +0.6$ cm/s (33%)
- Strong sensitivity across both experiments
- Dependent on landcover, domain and baseline values

Surface O₃ concentrations with complete RGS O₃ update

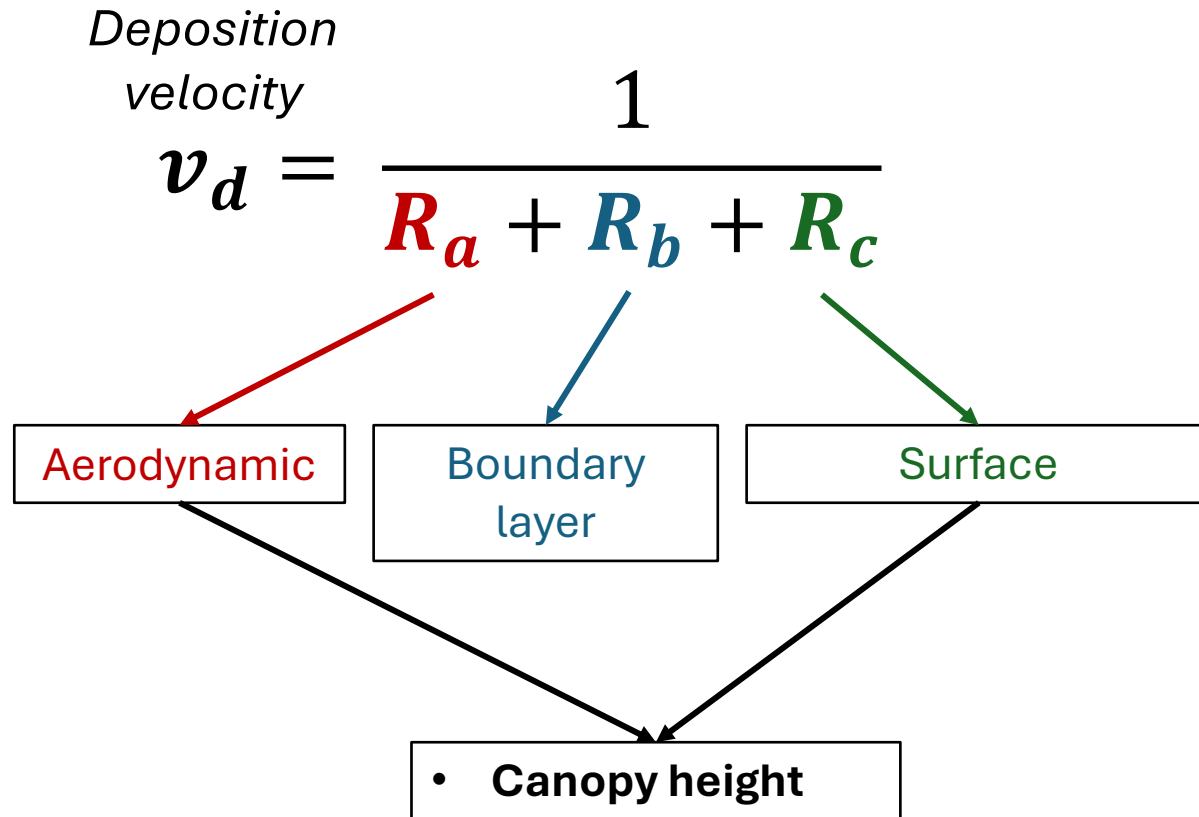
Surface O₃ difference (Full update - Base CHIMERE)



- Decrease of average O₃ surface on whole domain, up to -8 µg/m³
- Overall improvements on RMSE (-4 µg/m³) and Bias (- 6 µg/m³) at stations

- **Strong sensitivity of surface O₃ to RGS in CHIMERE**
- **Because O₃ deposition is limited by surface resistance R_c**

Canopy height z_{canopy} controls on O_3 deposition velocity



- Update z_{canopy} based on EMEP parameterization
- z_0 momentum roughness length computed as $0.1 z_{\text{canopy}}$
- Also affects friction velocity u^*

Canopy height and momentum roughness length update

	Needleleaf	Moorland	Med. Shrub
Canopy height (m)	15	0.5	3

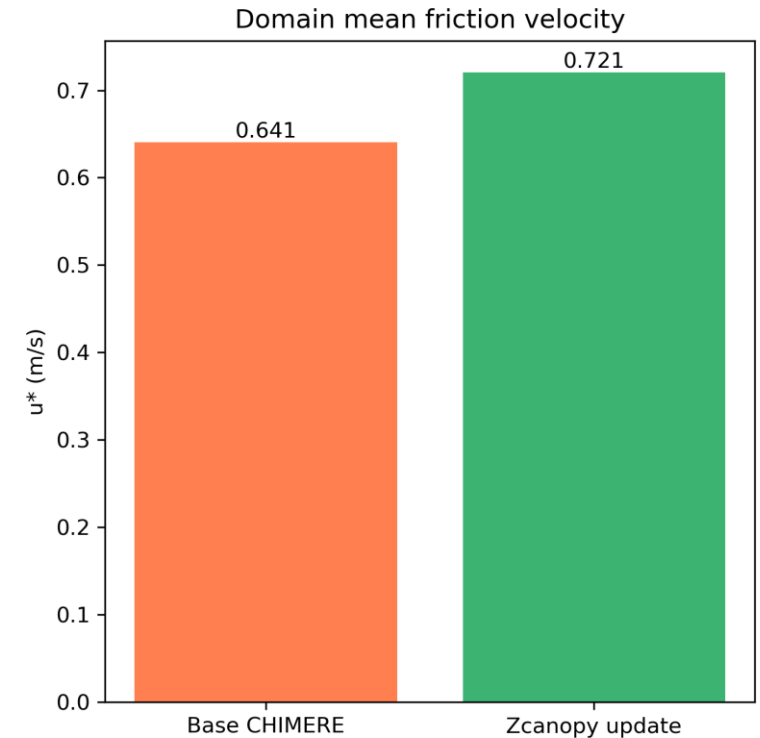
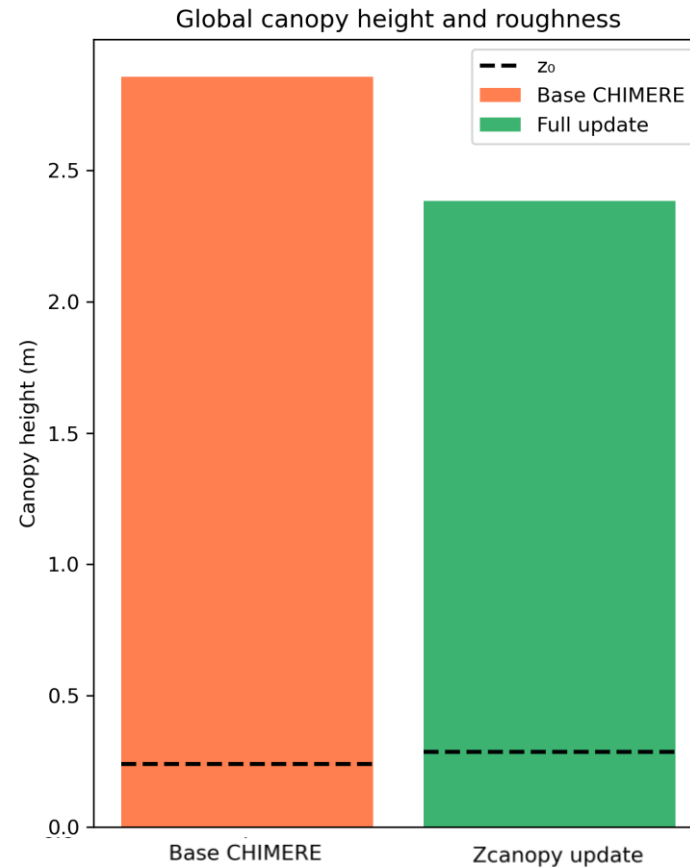


	Needleleaf	Moorland	Med. Shrub
Canopy height (m)	8	0.3	2

Wetlands	Tundra	Urban
0	0	0



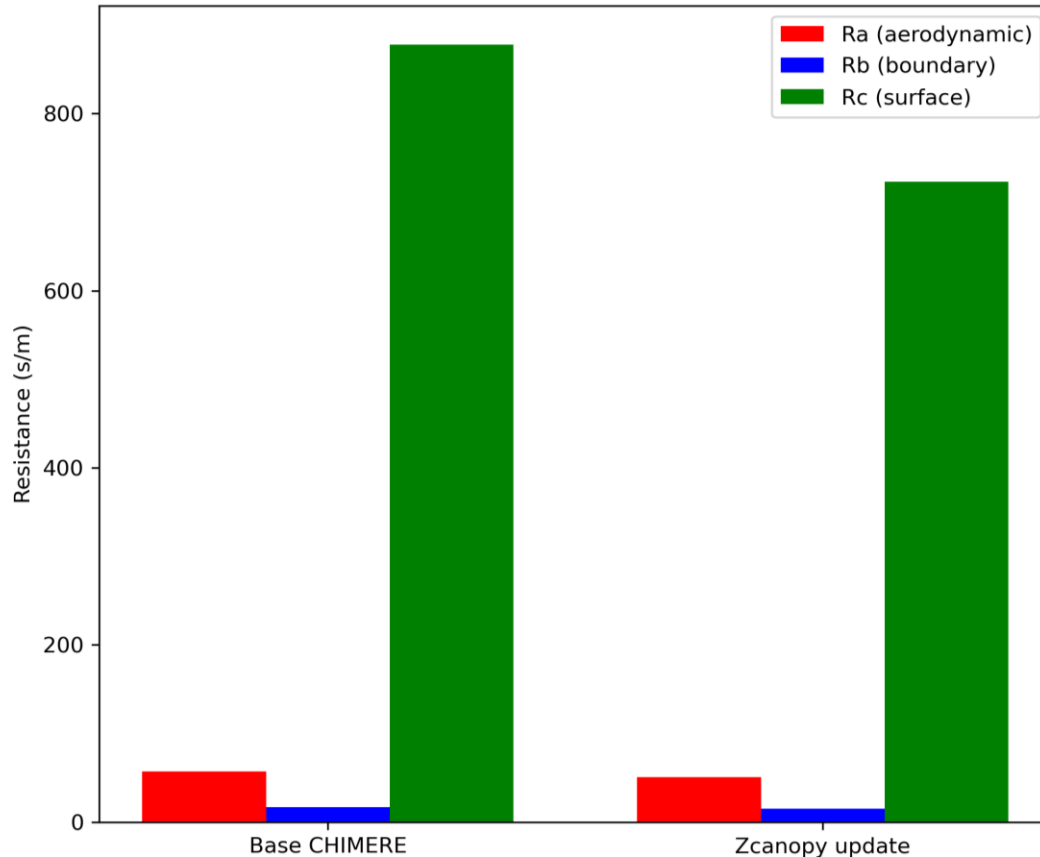
Wetlands	Tundra	Urban
0.5	0.5	10



- ~10% decrease for z_{canopy}
- ~10% increase for z_0
- ~10% increase for u^*

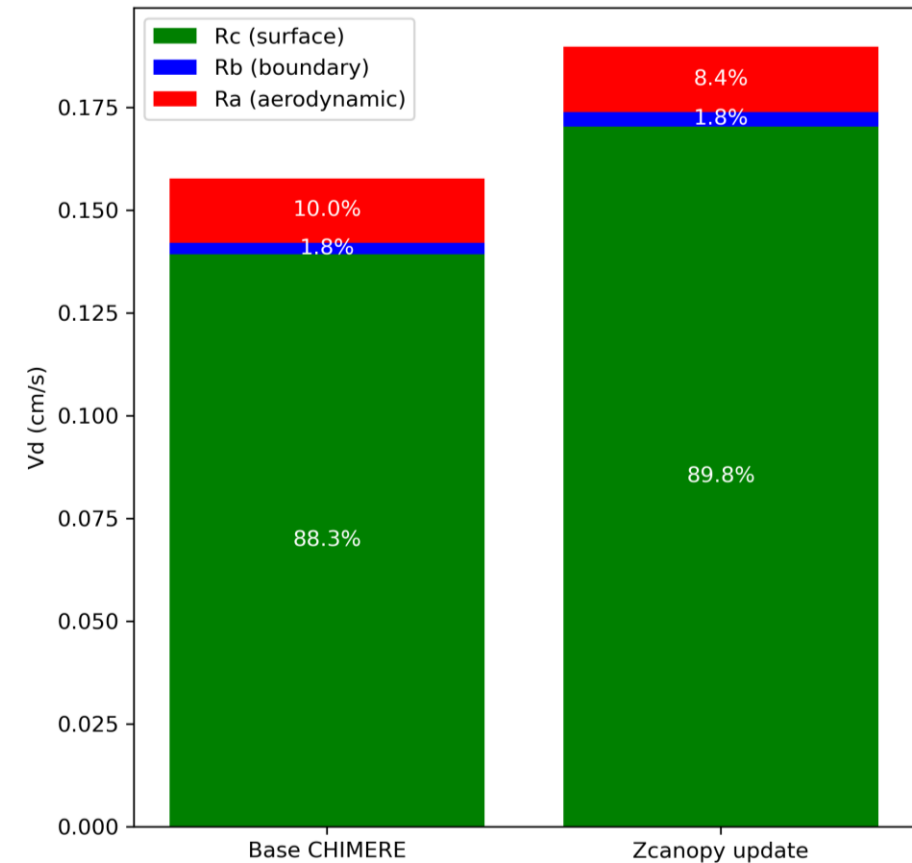
Canopy height update effect on deposition resistances

O₃ deposition resistances



- $R_a \sim -10\%$
- $R_c \sim -16\%$
- z_{canopy} update impacts both aerodynamic and surface resistance but $R_c \gg R_a$

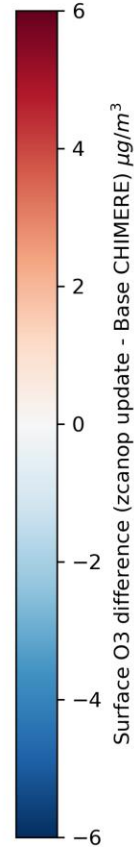
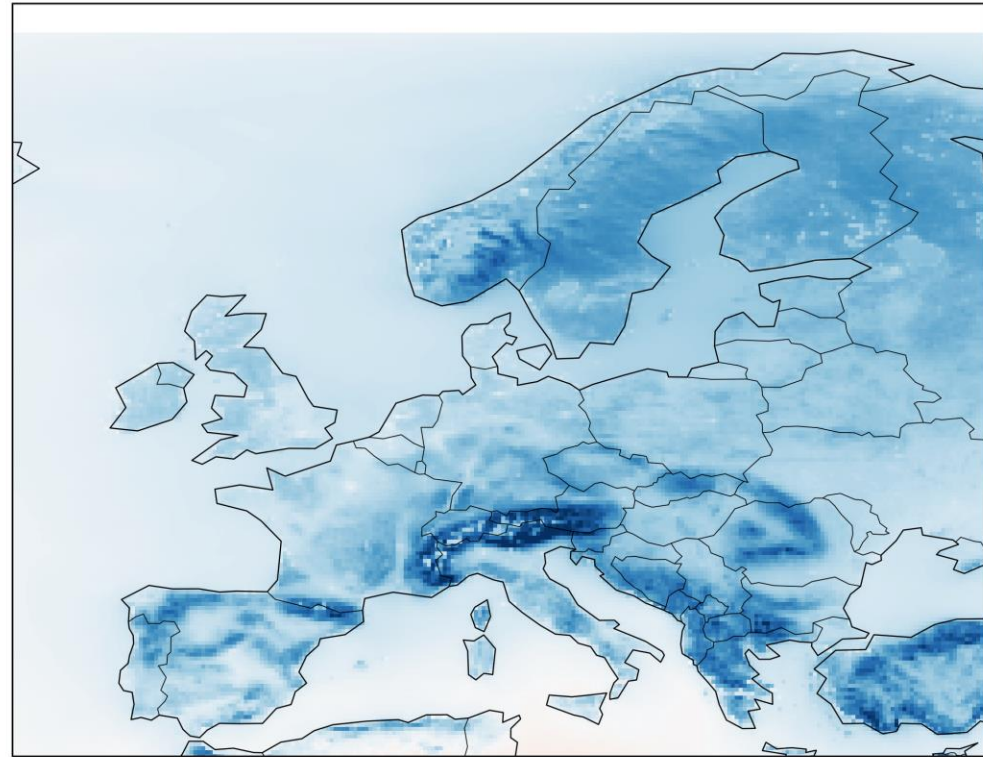
O₃ deposition velocity



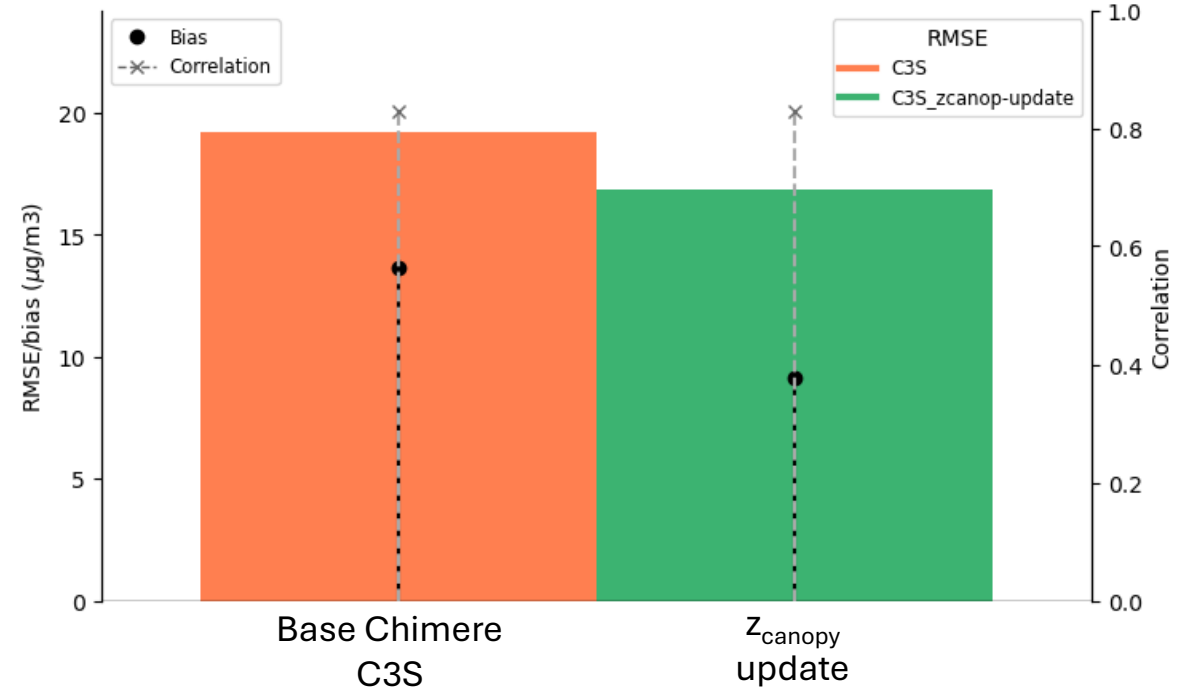
- Vd increase by 0.03 cm/s (~20%)
- Effect from z_{canopy} , z_0 and u^* on R_c changes

Canopy height update effect on O₃ concentrations

Surface O₃ difference (zcanop update - Base CHIMERE)

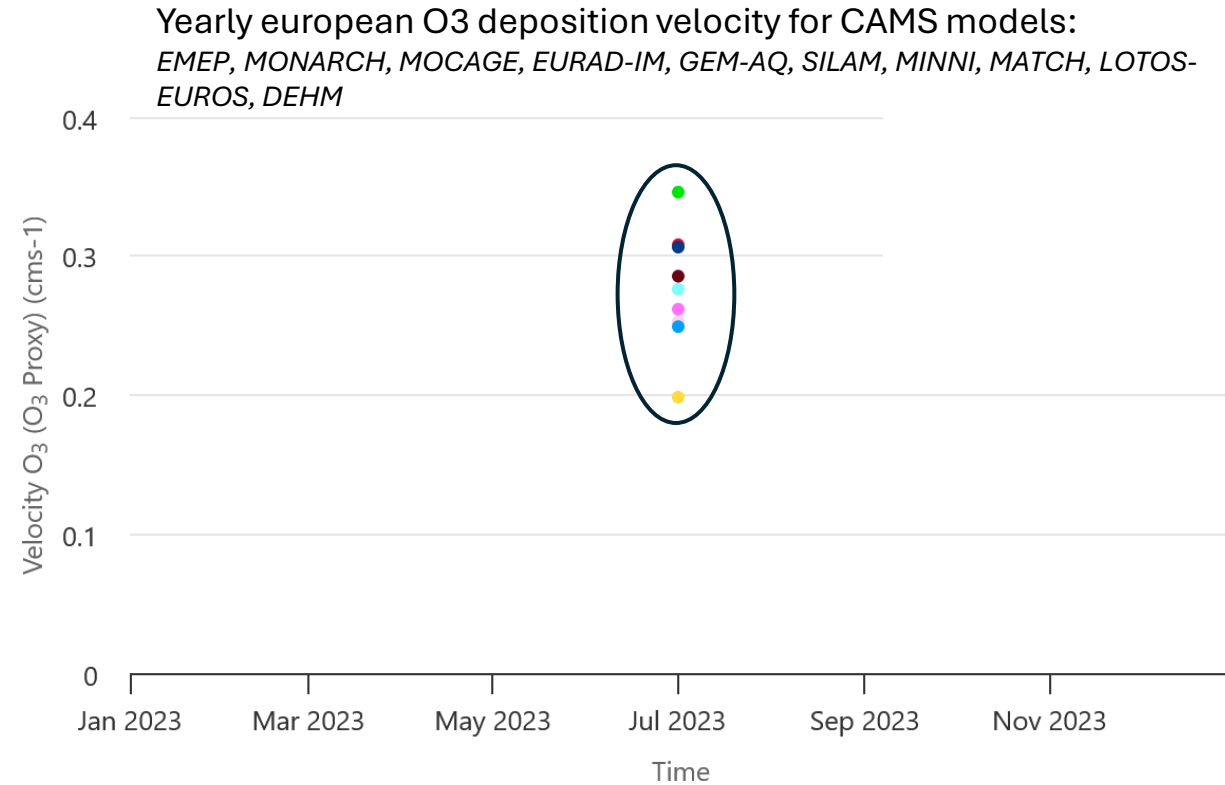
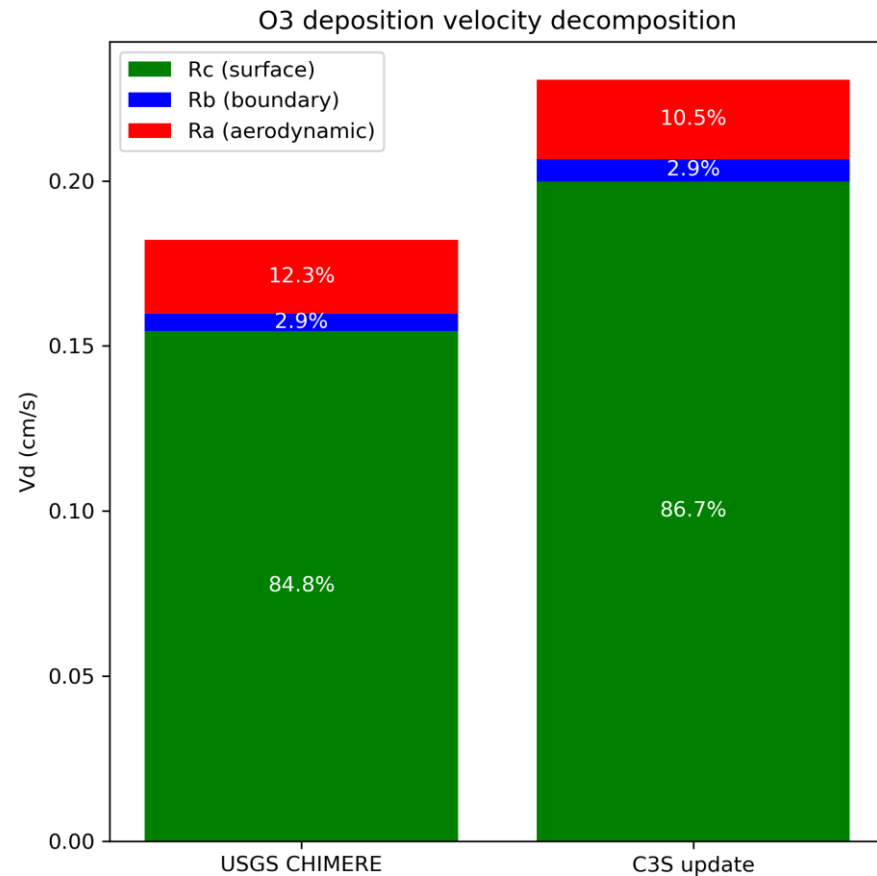


O₃, daily mean at stations, 2022, Europe domain



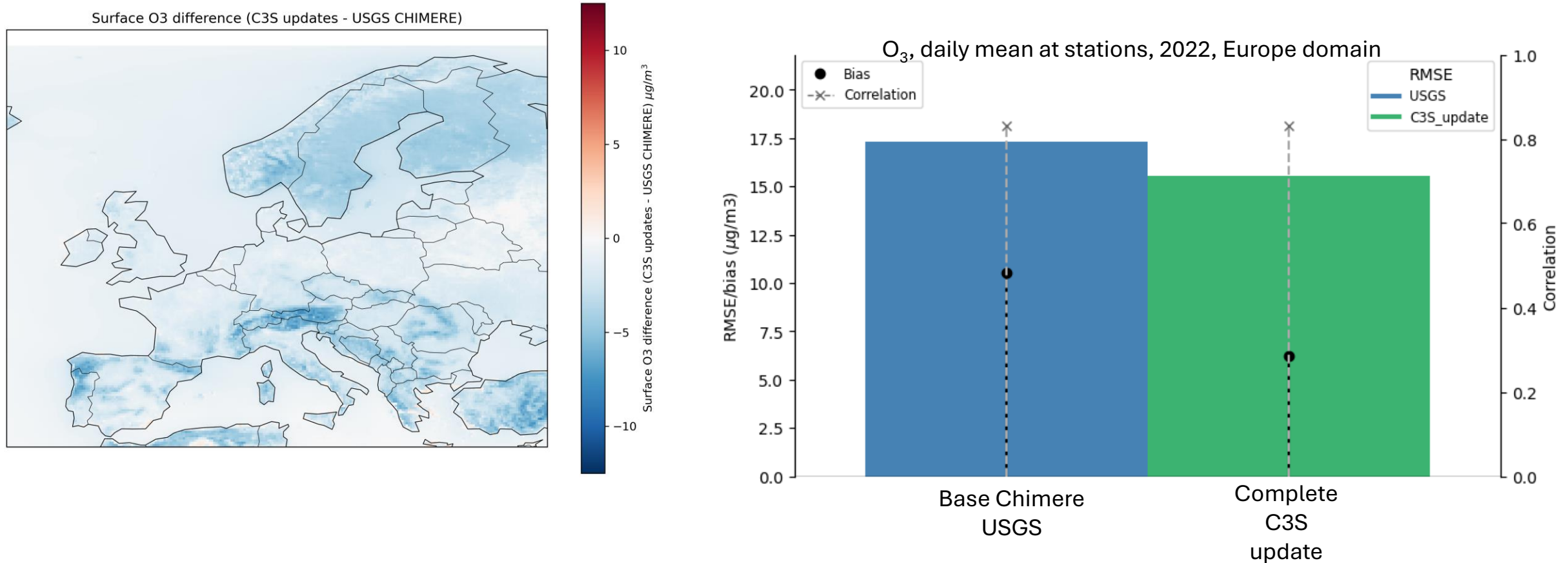
- O₃ surface concentration overall decrease, up to -6 µg/m³ over Alps
- RMSE (-2 µg/m³) and Bias (-5 µg/m³) improvements
- Strong sensitivity of CHIMERE performances to z_{canopy} and z_0 with R_c
- Expect an important effect on species/conditions limited by R_a

All updates O₃ deposition velocity against CAMS models



- Increase deposition velocity over Europe from 0.18 to 0.23 cm/s
- More in line with other regional CAMS models (0.2 – 0.35 cm/s yearly average)

All updates against Base CHIMERE with USGS



- Yearly surface O₃ decreases over most of Europe:
 - $-2 \mu\text{g}/\text{m}^3$ on average, locally down to $-13 \mu\text{g}/\text{m}^3$
- Stations RMSE and Bias improve relative to previous USGS configuration
- The combined effect is sub-additive but remains significant

Update summary

- CAMS landcover update to C3S
- 30 years difference with previous USGS landcover
- Fit CHIMERE land parameters to new landcover

- Strong effect of land parameters on O_3 deposition velocity:
 - RGS O_3 $\searrow$ **surface resistance** $\searrow$ O_3 surface concentration $\searrow$
 - $\searrow z_{\text{canopy}}$ and $z_0 \nearrow$ **surface & aerodynamic resistance** $\searrow$ O_3 surface concentration $\searrow$
- Updating to literature values lead to a decrease in baseline surface O_3
- **Strongly dependent on the landcover and domain used**

- Perspectives for other updates:
 - Database tree height for vegetation
 - LAI dynamic with meteorology

**Thank you for listening !
Questions ?**

LAI/SAI/phenology update

Current implementation:

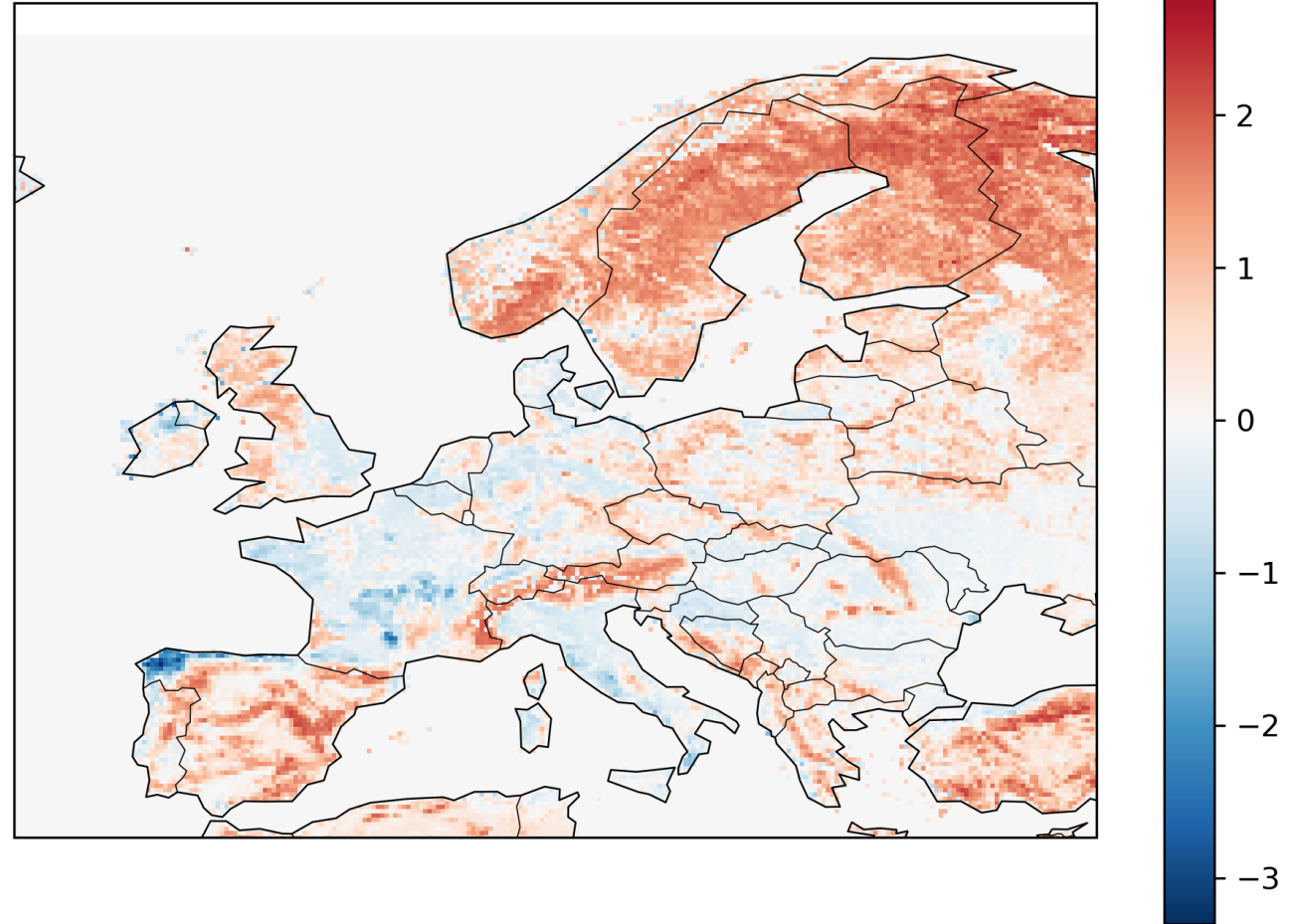
- Monthly values
- Satellite LAI MODIS
- SAI = LAI
- No dependency on landcover



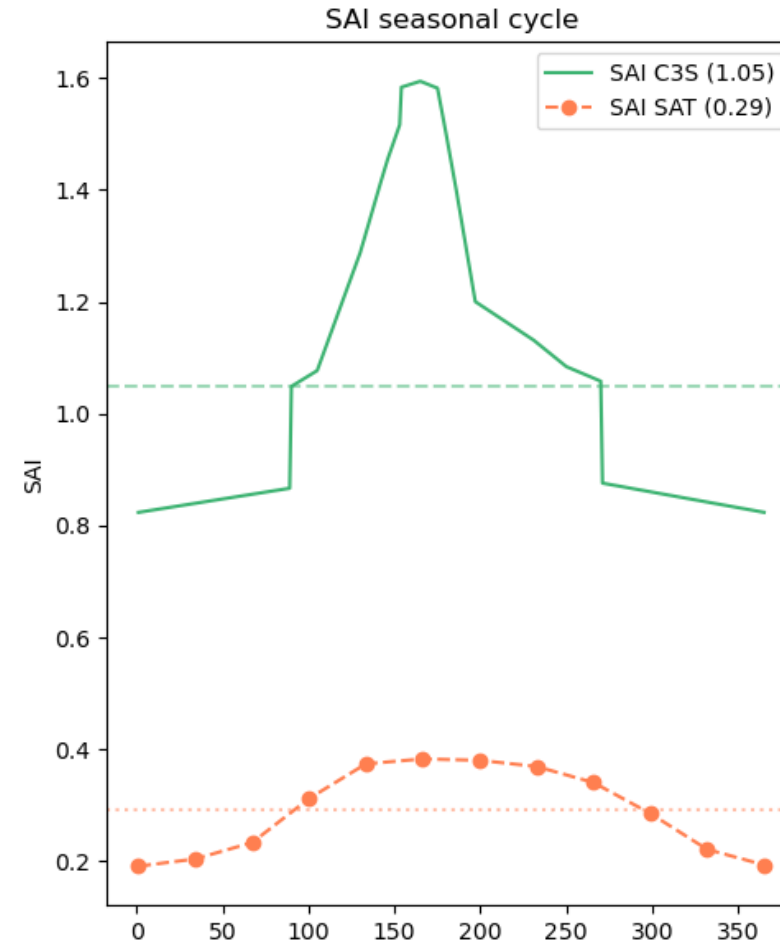
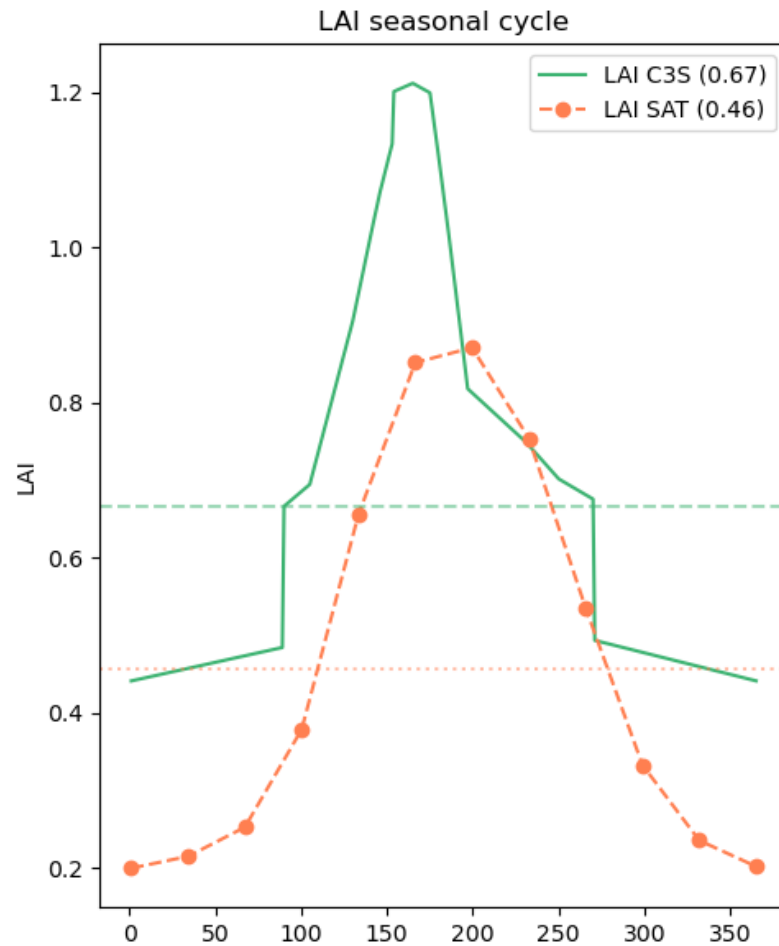
Test implementation:

- Daily values
- Land-use dependent vegetation
- LAI, SAI and phenology per vegetation type (Emberson et al., 2000)

Yearly average LAI difference
C3S – Satellite

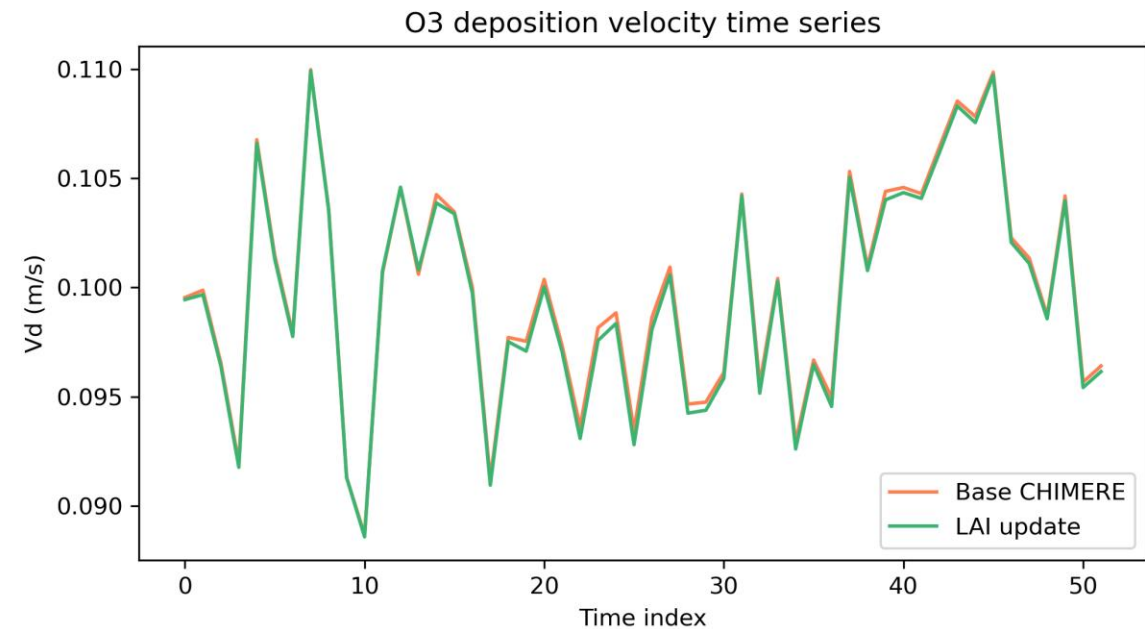
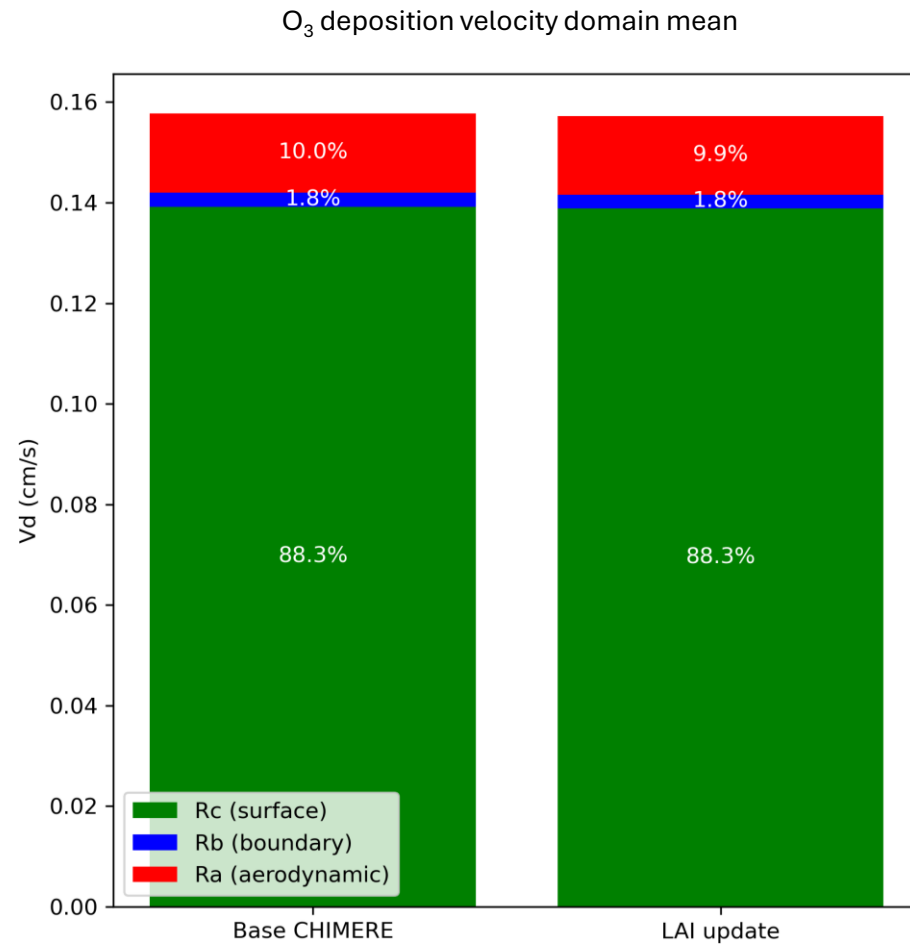


Differences in LAI spatial and temporal patterns over Europe



- Strong spatial discrepancies
- Differences in seasonal amplitude and timing
- Impact on deposition seasonality and magnitude ?

LAI/SAI/phenology controls on O₃ deposition velocity



- Almost no effect on domain resistances and deposition velocities

LAI/SAI/phenology controls on surface resistance R_c

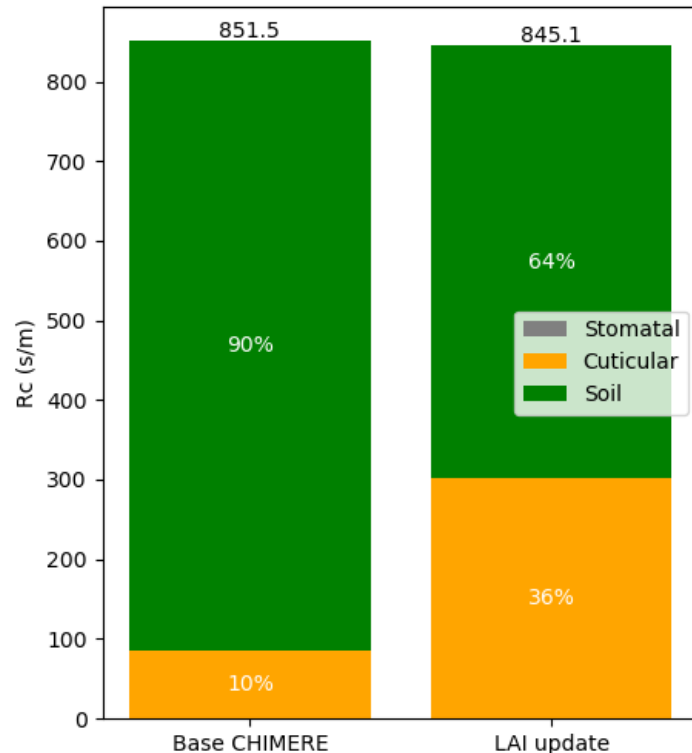
$$R_c = \frac{1}{G_{sto} + G_{cut} + G_{nonsto}}$$

$$G_{sto} \sim LAI f_{pheno} \dots \ll \frac{1}{R_c}$$

$$G_{cut} = \frac{SAI}{2500}$$

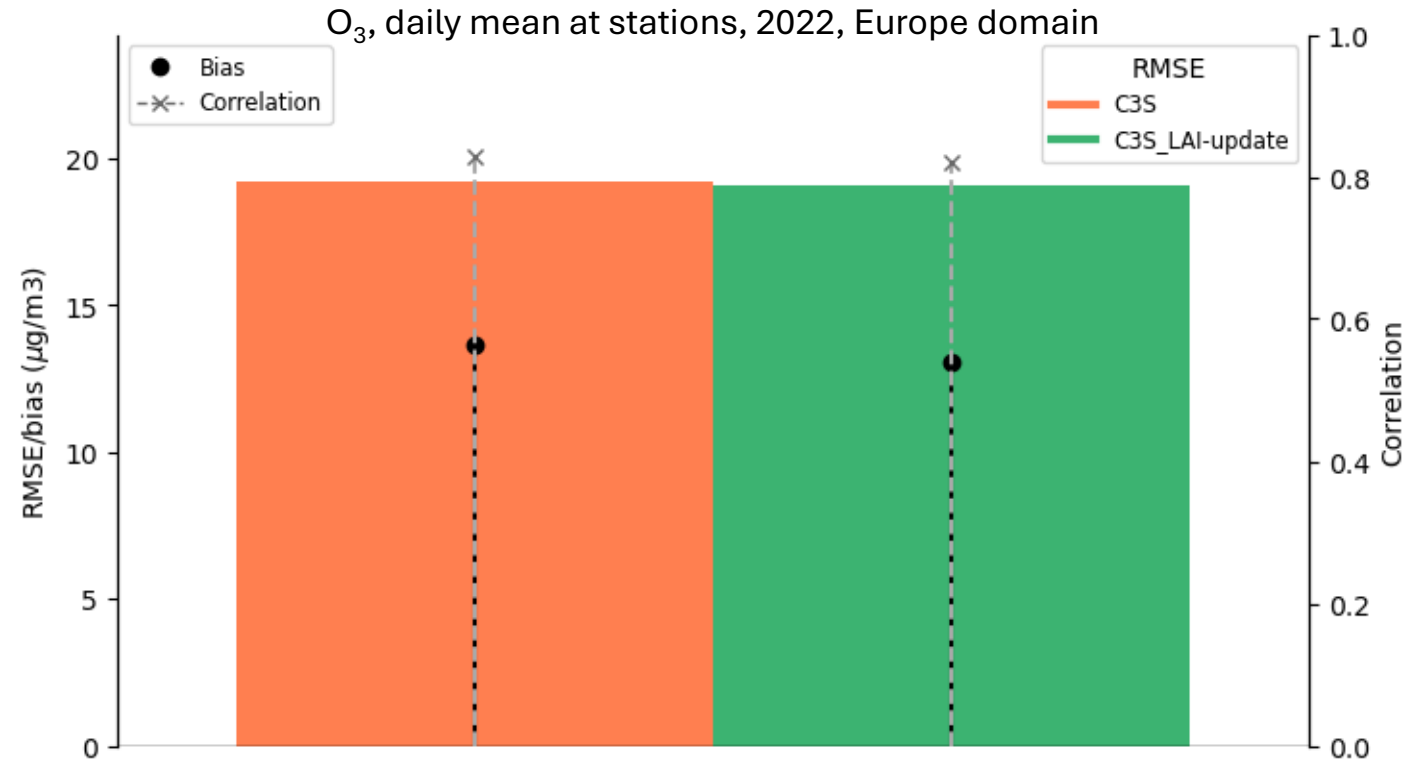
$$G_{nonsto} = \frac{1}{14 SAI \frac{z_{canopy}}{u^*} + RGS f_{tns} + \dots}$$

R_c domain mean with contributions to total conductance



- SAI strongly affects individual conductances:
 - Increases cuticular pathway (+330%)
 - Decreases non-stomatal pathway (-32%)
- Variations compensate and R_c remains nearly constant
- Effects of LAI and phenology buried in stomatal conductance

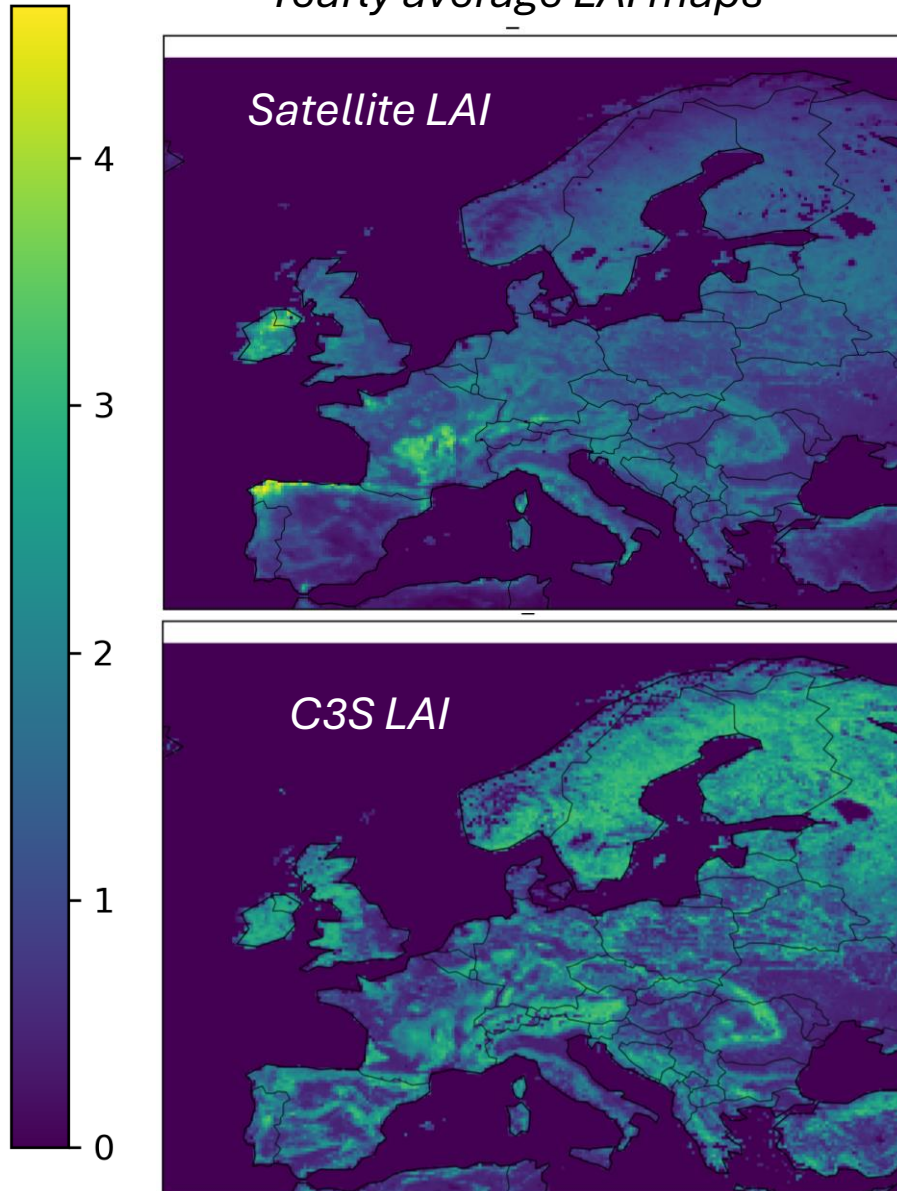
O₃ Performance under LAI update



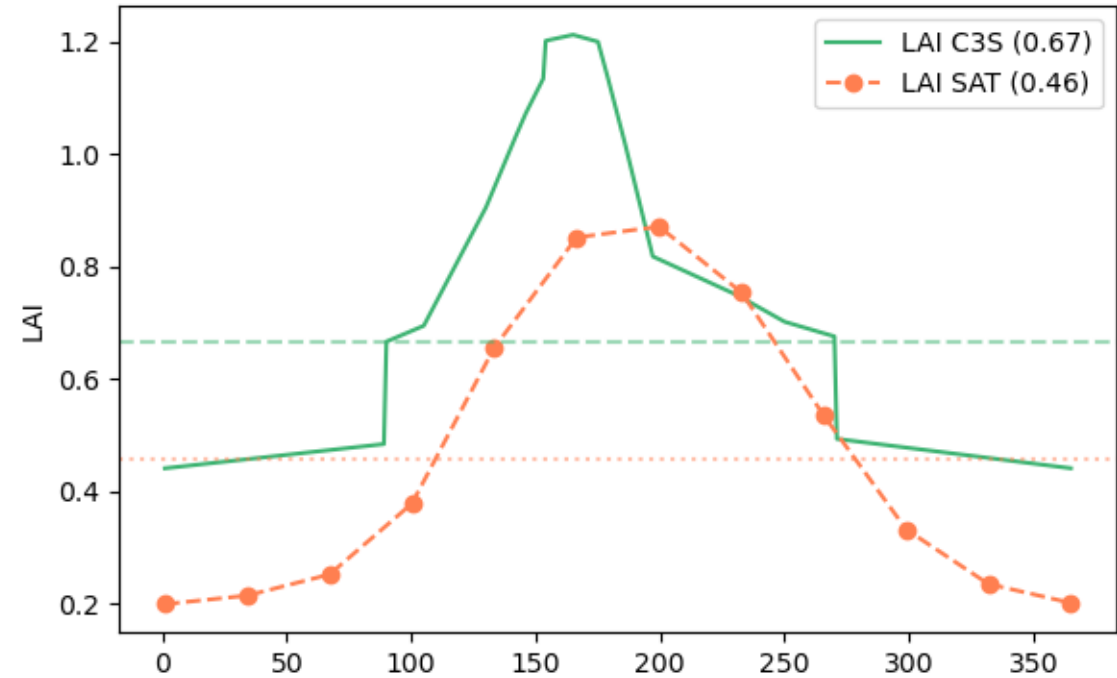
- Effect on yearly domain performances are negligible
- Tests on different domains and LAI parameterizations are necessary to assess potential effects on performances and deposition
- Tests on LAI map used for BVOC emissions

Differences in LAI spatial and temporal patterns over Europe

Yearly average LAI maps



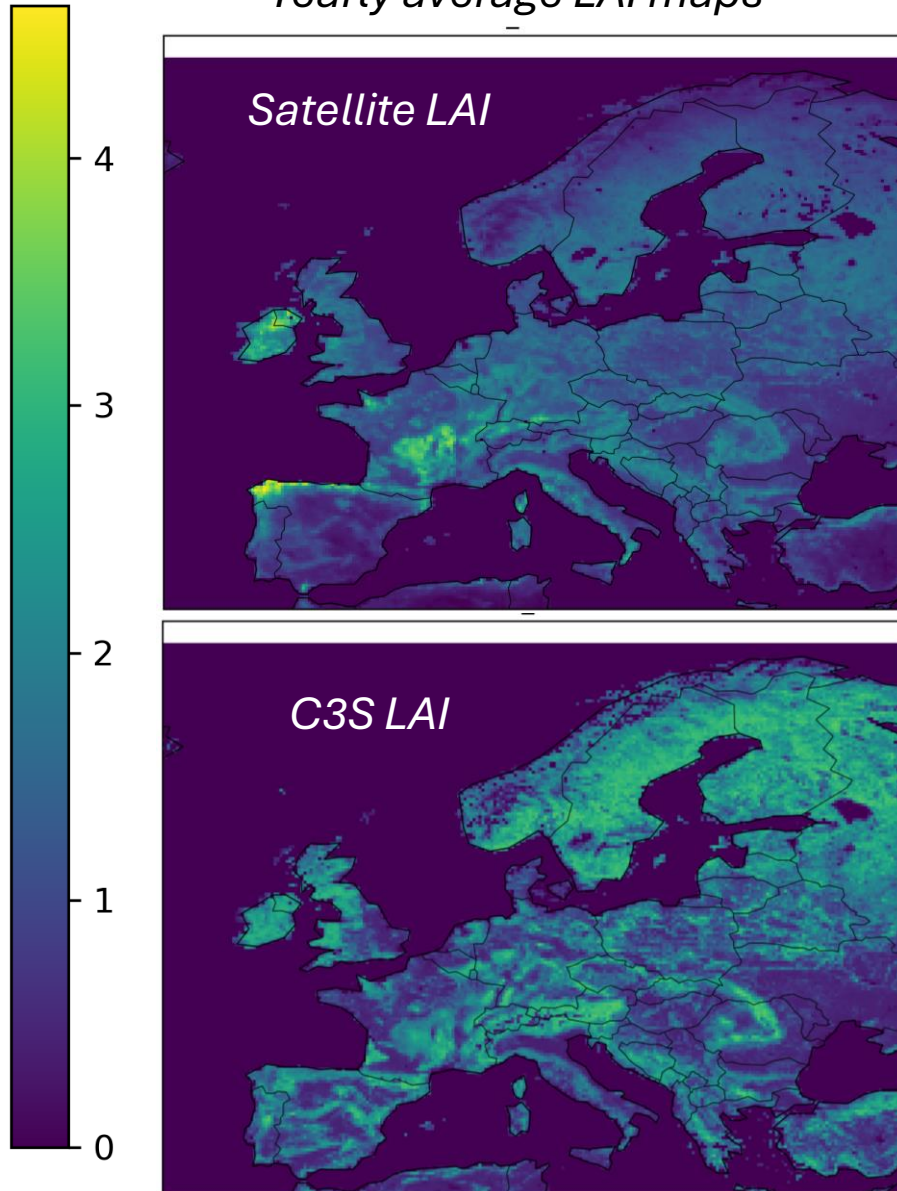
Spatial average LAI timeseries



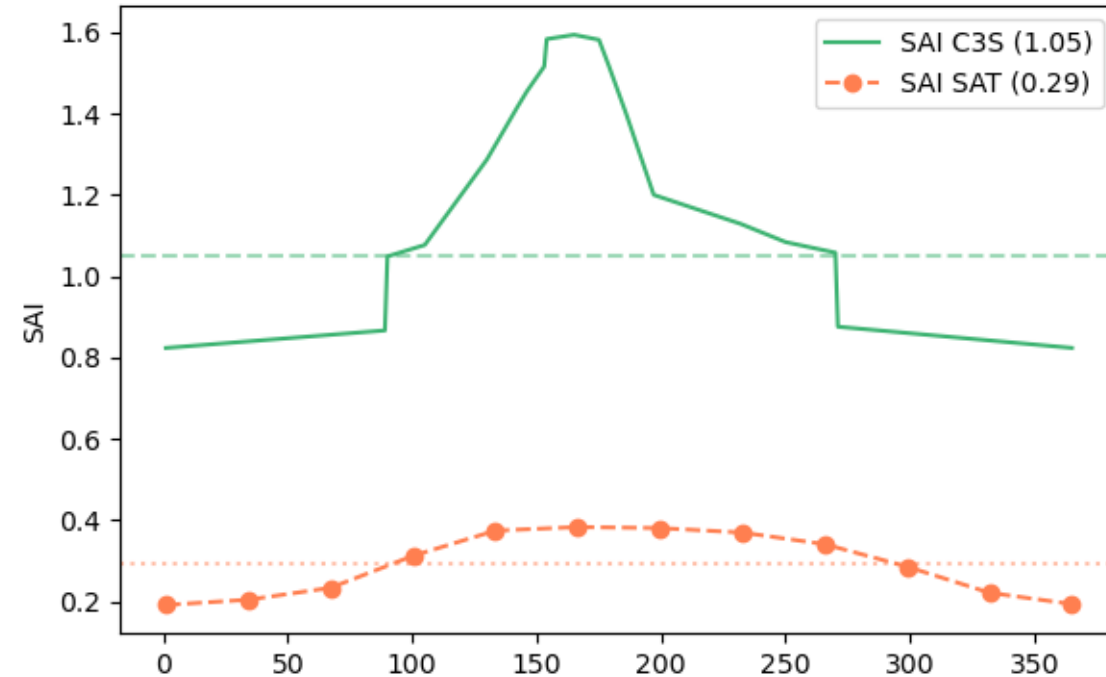
- Strong spatial LAI discrepancies
- Differences in LAI seasonal amplitude and timing
- Impact on deposition seasonality and magnitude

Differences in LAI spatial and temporal patterns over Europe

Yearly average LAI maps



Spatial average SAI timeseries



- Strong spatial LAI discrepancies
- Differences in LAI seasonal amplitude and timing
- Impact on deposition seasonality and magnitude

Complete RGS O₃ update (Clifton et al., 2020)

	Conif	Decid	Needle	Broadleaf	Bor. Crop	Med. Crop	Root crop	Moorland
<i>RGS (s.m⁻¹)</i>	200	200	200	200	200	200	200	400



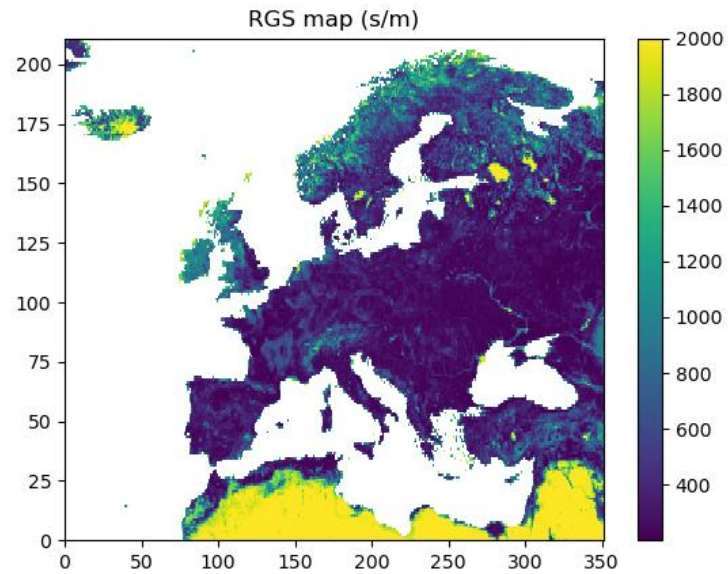
	Conif	Decid	Needle	Broadleaf	Bor. Crop	Med. Crop	Root crop	Moorland
<i>RGS (s.m⁻¹)</i>	200	200	200	200	200	200	200	200

Grasslands	Med. Shrub	Wetlands	Tundra	Desert	Water	Ice	Urban
1000	200	2000	400	2000	2000	2000	400

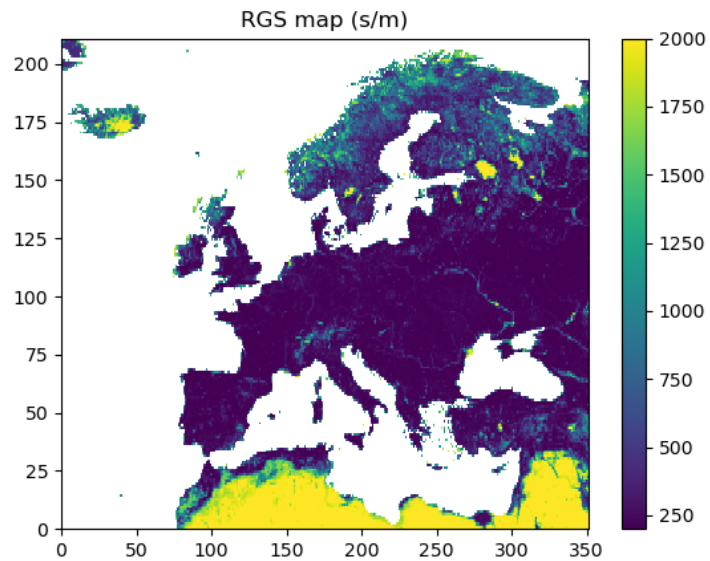


Grasslands	Med. Shrub	Wetlands	Tundra	Desert	Water	Ice	Urban
200	200	500	200	500	2000	7000	200

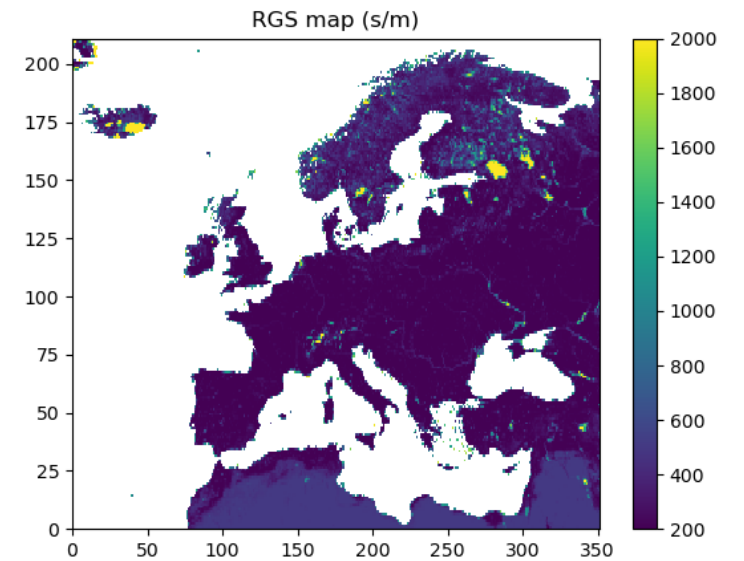
RGSO3 maps



Base

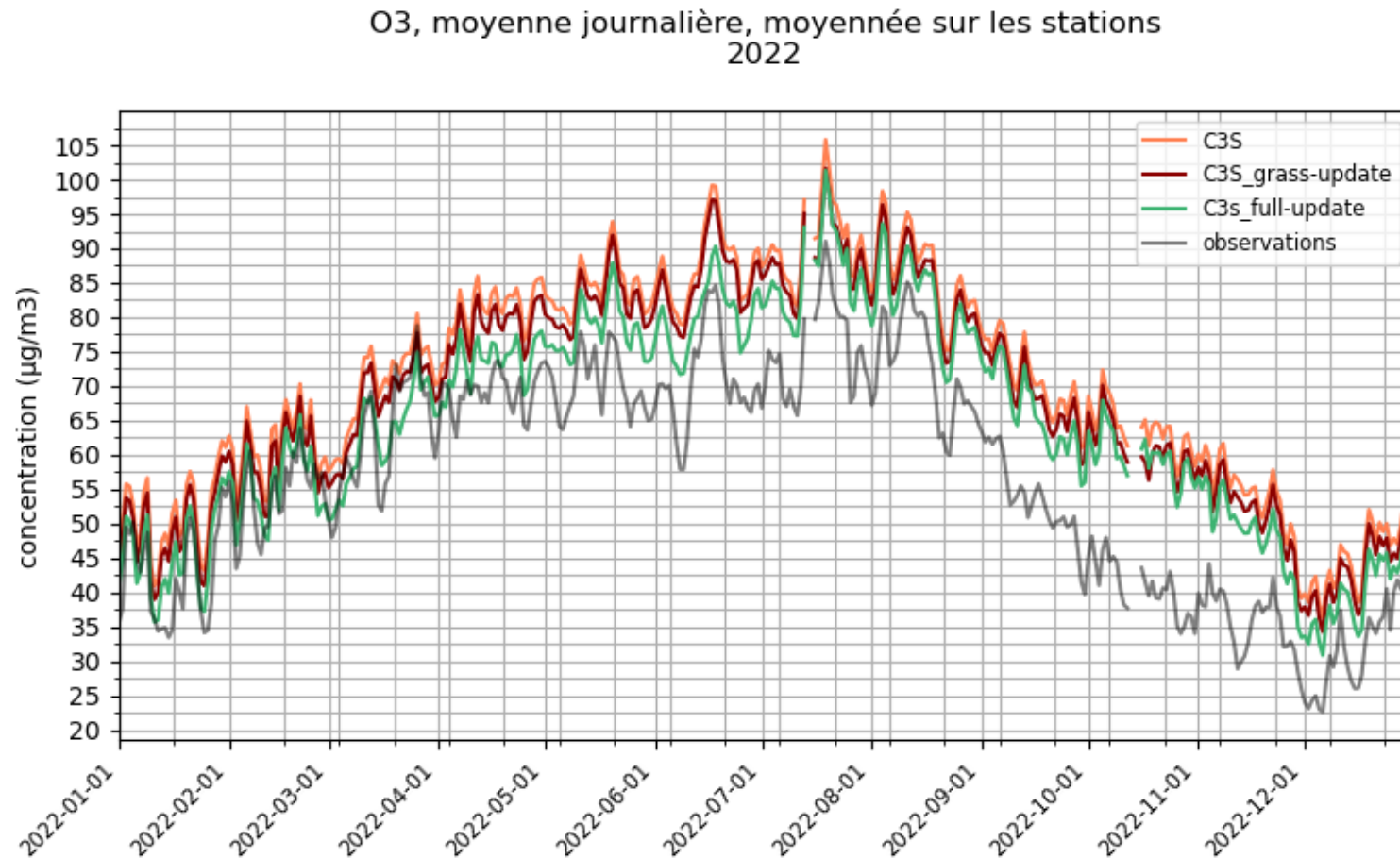


Grass=200



Full update

O3 mean timeseries



Complete z_{canopy} update

	Conif	Decid	Needle	Broadleaf	Bor. Crop	Med. Crop	Root crop	Moorland
$z_{canopy}(m)$	20	20	15	15	1	2	1	0.5



	Conif	Decid	Needle	Broadleaf	Bor. Crop	Med. Crop	Root crop	Moorland
$z_{canopy}(m)$	20	20	8	15	1	2	1	0.5

Grasslands	Med. Shrub	Wetlands	Tundra	Desert	Water	Ice	Urban
0.5	3	0	0	0	0	0	0

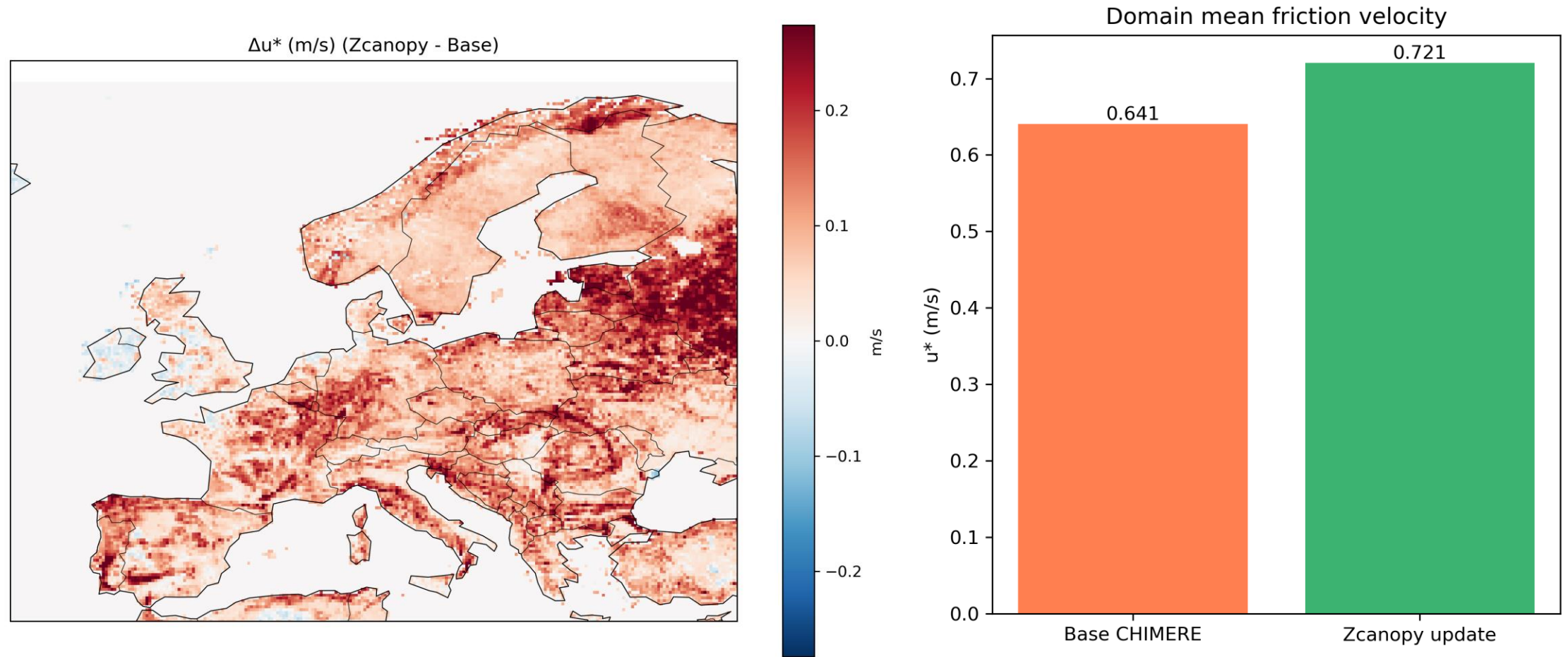


Grasslands	Med. Shrub	Wetlands	Tundra	Desert	Water	Ice	Urban
0.3	2	0.5	0.5	0	0	0	10

#	Landuse	$z_{0,min}$ (m)	$z_{0,max}$ (m)	#	Landuse	$z_{0,min}$ (m)	$z_{0,max}$ (m)
1	urban and built-up land	0.50	0.50	15	mixed forest	0.20	0.50
2	dryland cropland and pasture	0.05	0.15	16	water bodies	0.0001	0.0001
3	irrigated cropland and pasture	0.02	0.10	17	herbaceous wetland	0.20	0.20
4	mixed of (2) and (3)	0.05	0.15	18	wooded wetland	0.40	0.40
5	cropland/grassland mosaic	0.05	0.14	19	barren	0.01	0.01
6	cropland/woodland mosaic	0.20	0.20	20	herbaceous tundra	0.10	0.10
7	grassland	0.10	0.12	21	wooded tundra	0.30	0.30
8	shrubland	0.01	0.05	22	mixed tundra	0.15	0.15
9	mixed shrubland/grassland	0.01	0.06	23	bare ground tundra	0.05	0.10
10	savanna	0.15	0.15	24	snow or ice	0.001	0.001
11	deciduous broadleaf forest	0.50	0.50	25	playa	0.01	0.01
12	deciduous needleleaf forest	0.50	0.50	26	lava	0.15	0.15
13	evergreen broadleaf forest	0.50	0.50	27	white sand	0.01	0.01
14	evergreen needleleaf forest	0.50	0.50	28	ocean	0.0	0.0

	Conif	Decid	Needle	Broadleaf	Bor. Crop	Med. Crop	Root crop	Moorland
$RGS (s.m^{-1})$	2	2	0.8	1.5	0.1	0.2	0.1	0.05
	Grasslands	Med. Shrub	Wetlands	Tundra	Desert	Water	Ice	Urban
	0.03	0.2	0.05	0.05	0	0	0	1

Canopy height effect on u^*



- Increase of u^* on most of the domain, especially Eastern forests
- ~10% average increase for ~10% z_{canopy} decrease