

# Supporting Information for ”Atmospheric Transport Modeling of CO<sub>2</sub> with Neural Networks”

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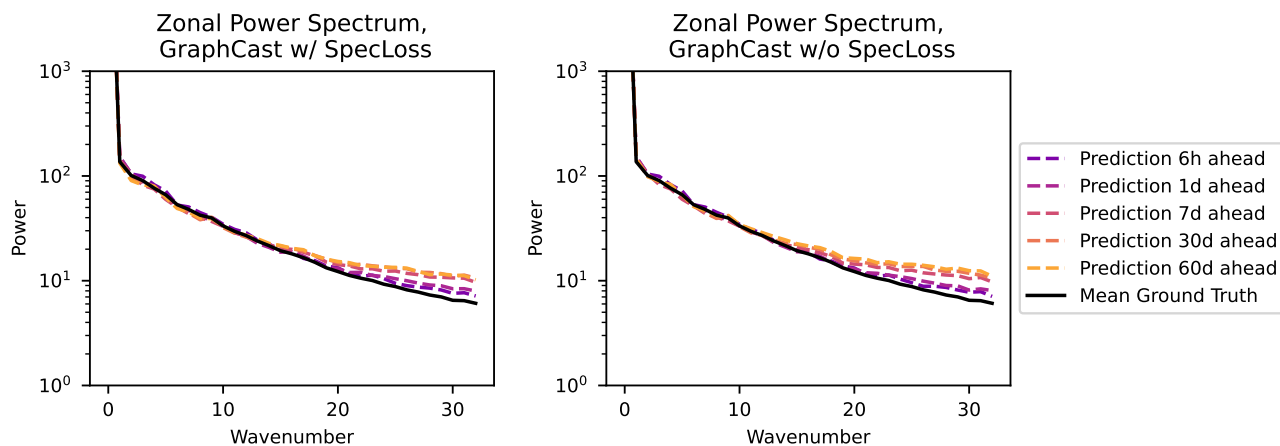
## Contents of this file

1. Table S1
2. Figures S1 to S13

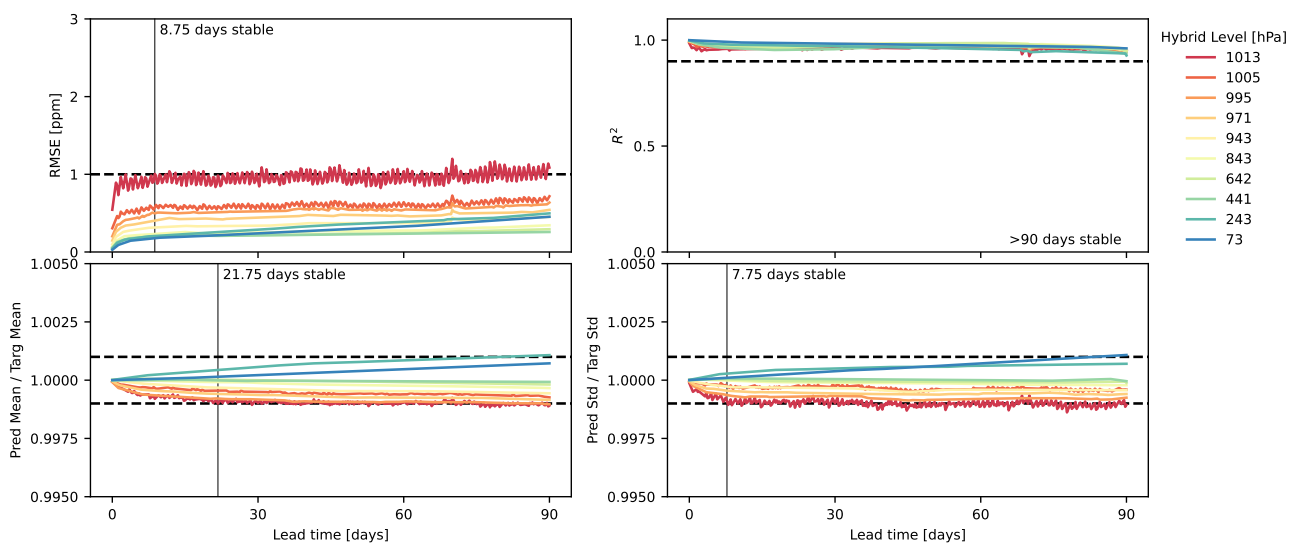
In the supplementary information we provide fig. 4–7 from the main text, but for the three baseline models UNet, GraphCast SFNO. In addition we provide table S1, which compiles a list of the variables used in this study and figure S1, which compares zonal power spectra for the SpecLoss ablation of GraphCast.

variable	3D	time	unit	description
<i>Input Variables</i>				
co2massmix	✓	$t$	$\frac{10^{-6}kgCO_2}{kgDryAir}$	CO <sub>2</sub> mass mixing ratio
airmass	✓	$t$	Pg	dry air mass
gph_bottom	✓	$t$	km	geopotential height at level bottom
gph_top	✓	$t$	km	geopotential height at level top
p_bottom	✓	$t$	hPa	pressure at level bottom
p_top	✓	$t$	hPa	pressure at level top
q	✓	$t$	$\frac{kg}{kg}$	specific humidity
t	✓	$t$	K	air temperature
u	✓	$t$	$\frac{m}{s}$	zonal wind speed (eastward)
v	✓	$t$	$\frac{m}{s}$	meridional wind speed (northward)
co2flux_anthro	✗	$t + \frac{1}{2}$	$\frac{kgCO_2}{m^2s}$	anthropogenic CO <sub>2</sub> surface flux
co2flux_land	✗	$t + \frac{1}{2}$	$\frac{kgCO_2}{m^2s}$	biospheric CO <sub>2</sub> surface flux
co2flux_ocean	✗	$t + \frac{1}{2}$	$\frac{kgCO_2}{m^2s}$	oceanic CO <sub>2</sub> surface flux
blh	✗	$t$	m	planetary boundary layer thickness
tisr	✗	$t$	$\frac{J}{m^2}$	total incoming solar radiation
cell_area	✗	–	$m^2$	cell area at the surface
orography	✗	–	$\frac{m^2}{s^2}$	surface geopotential
<i>Output Variables</i>				
co2massmix	✓	$t + 1$	$\frac{10^{-6}kgCO_2}{kgDryAir}$	CO <sub>2</sub> mass mixing ratio

**Table S1.** The variables used in the CarbonBench dataset to train deep neural network emulators of atmospheric tracer transport.



**Figure S1.** Zonal power spectrum for an ablation of GraphCast with (left) and without (right) the SpecLoss. Spectra are computed in zonal direction and averaged over latitude and vertical level, the different lines correspond to different lead times.



**Figure S2.** Same as fig. 4 but for UNet.

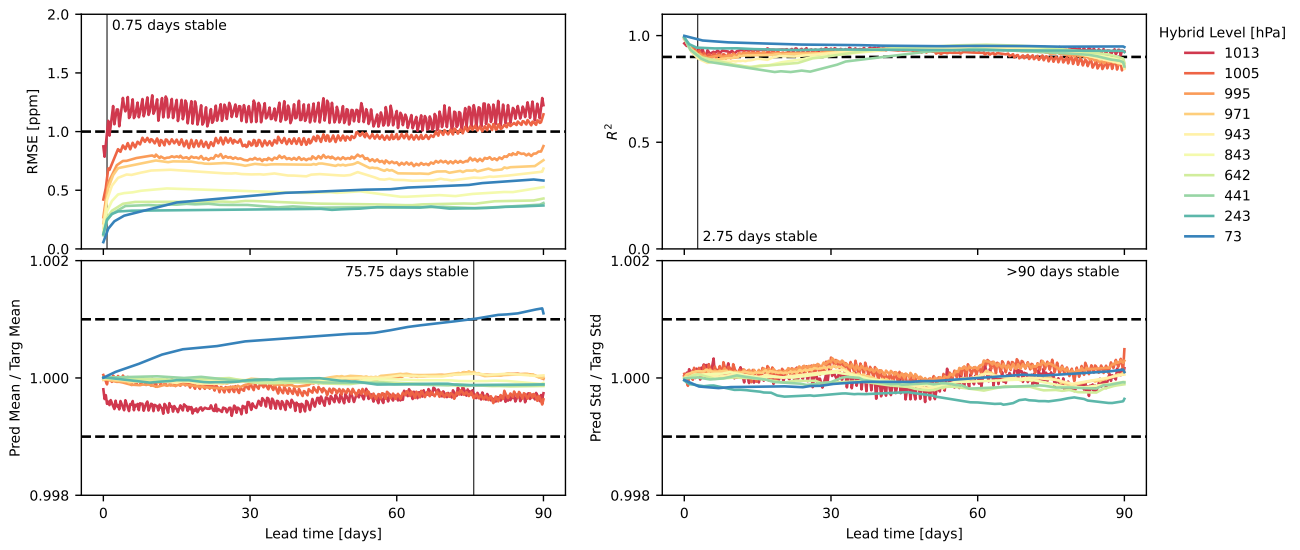


Figure S3. Same as fig. 4 but for GraphCast.

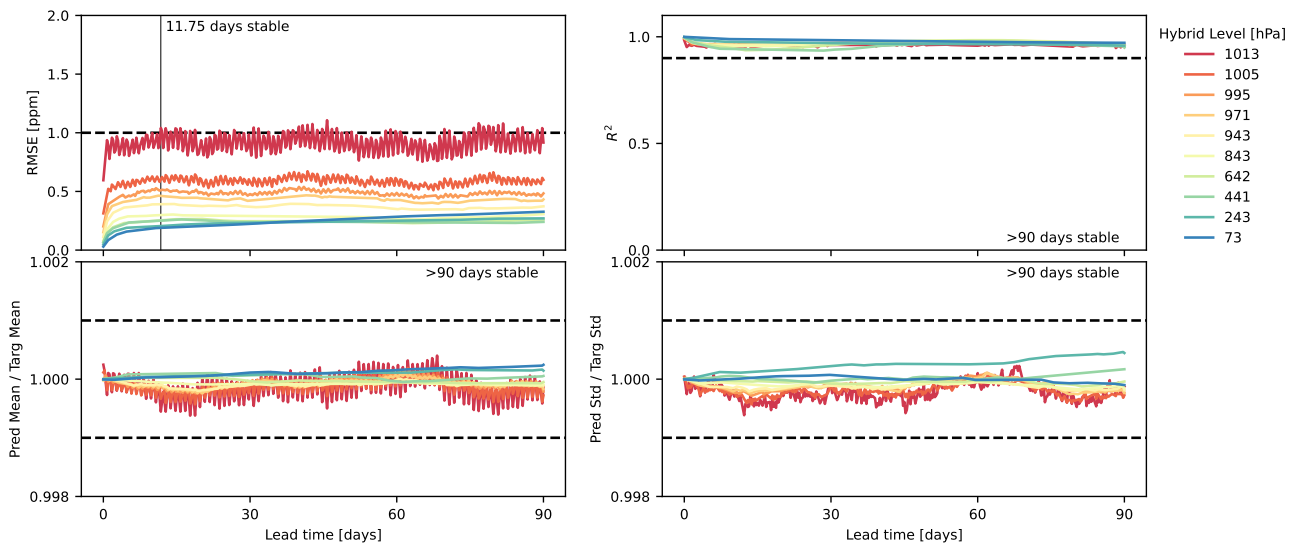


Figure S4. Same as fig. 4 but for SFNO.

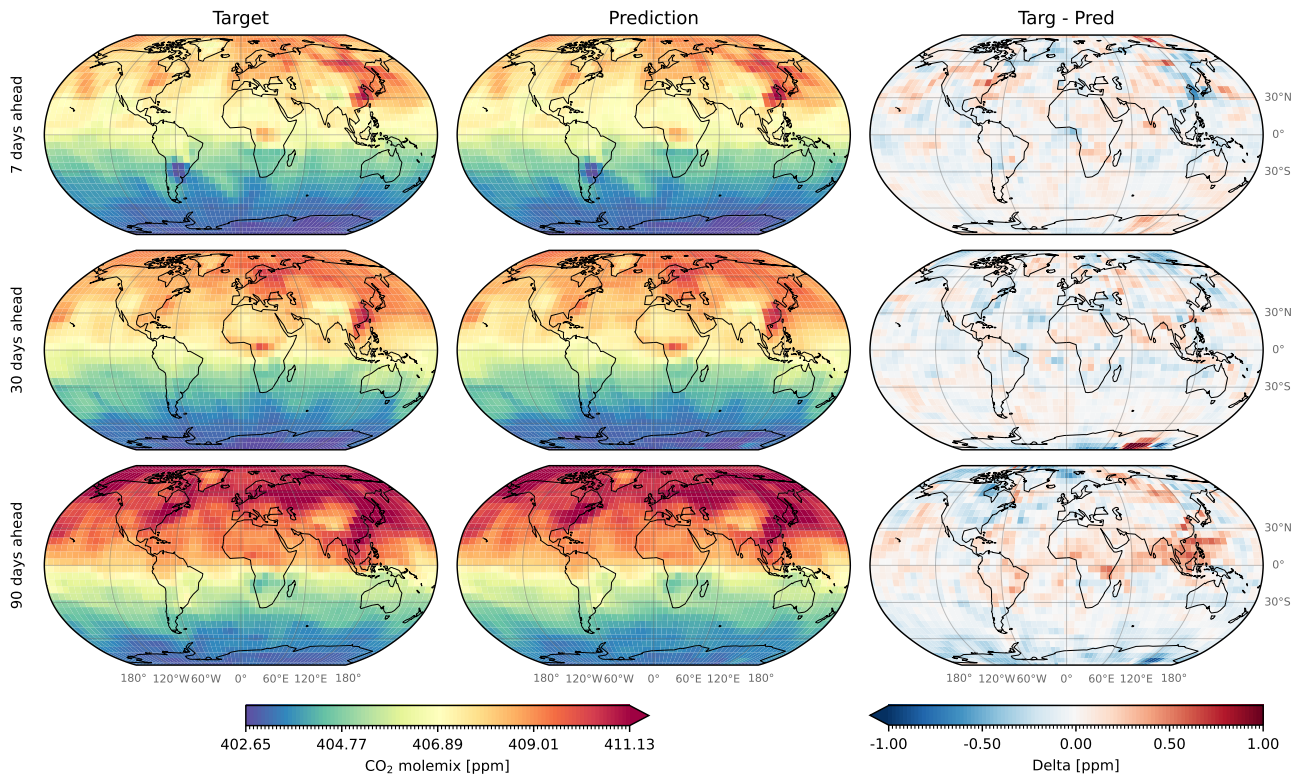


Figure S5. Same as fig. 5 but for UNet.

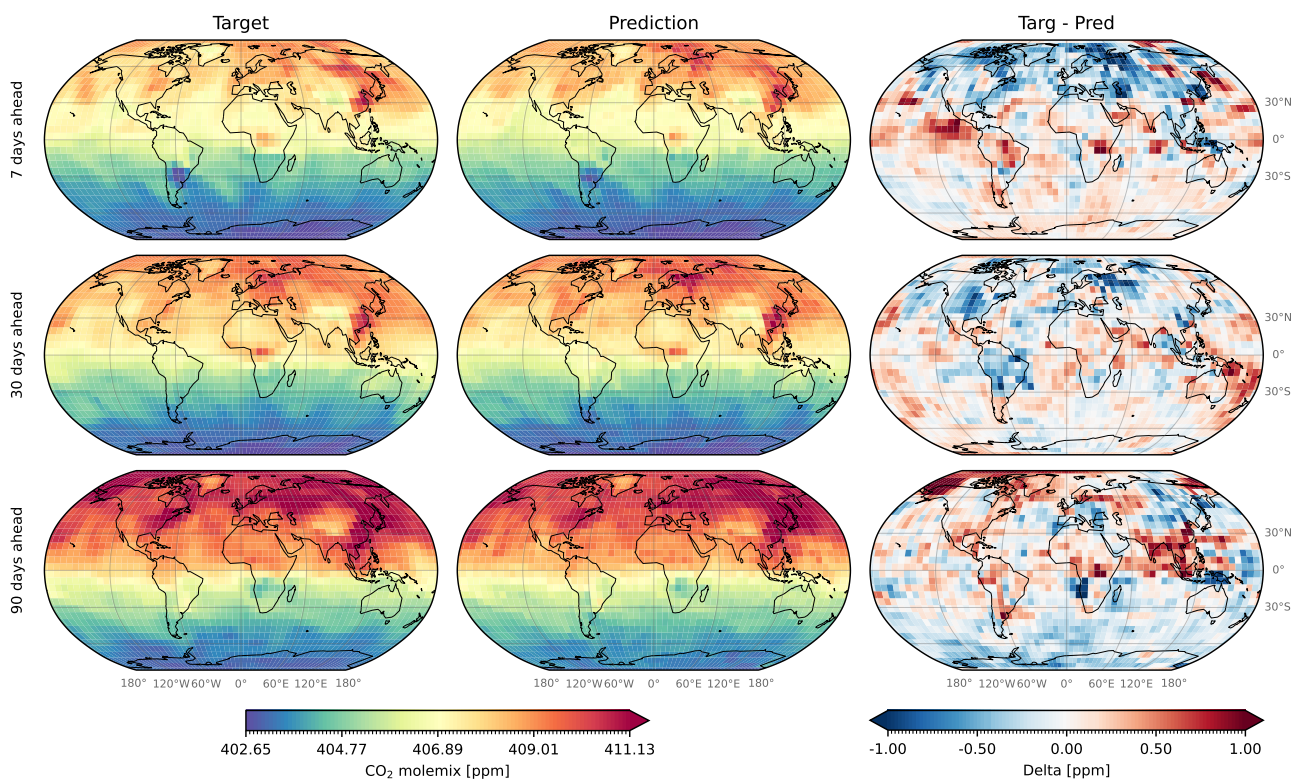


Figure S6. Same as fig. 5 but for GraphCast.

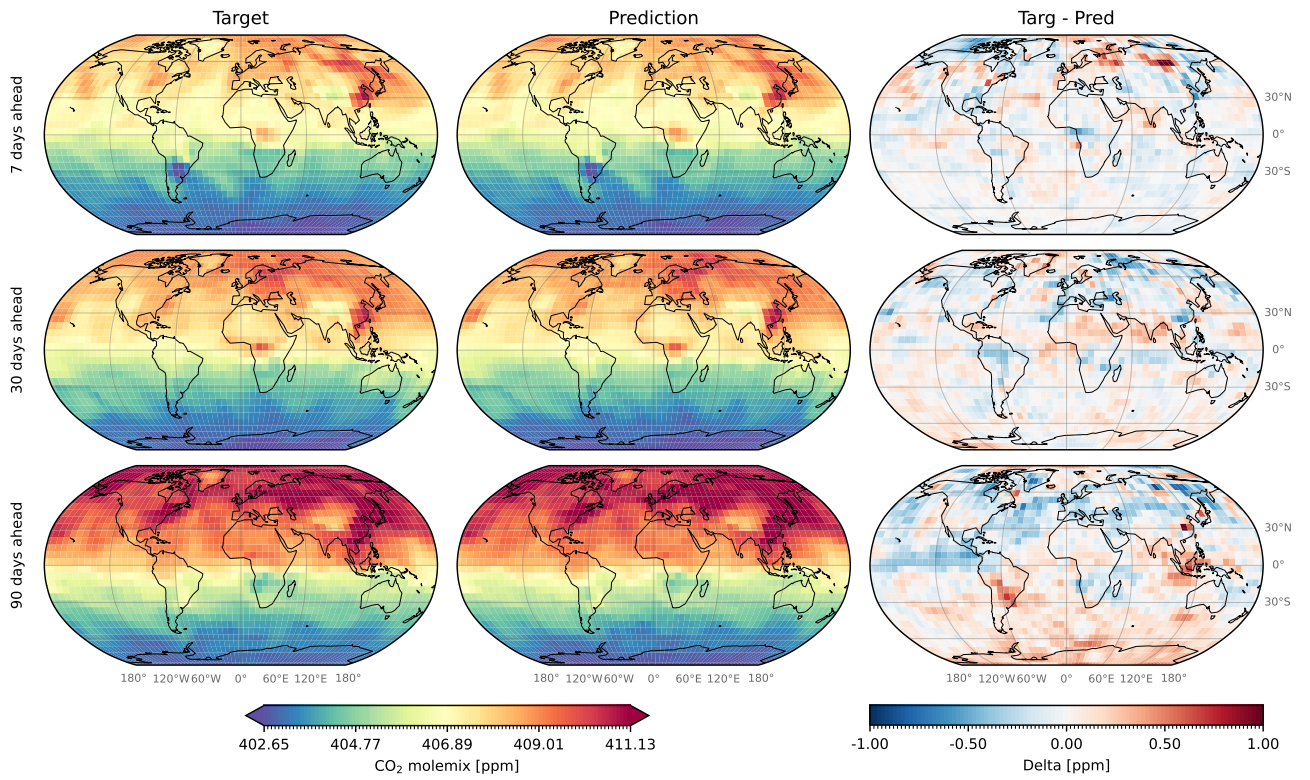


Figure S7. Same as fig. 5 but for SFNO.

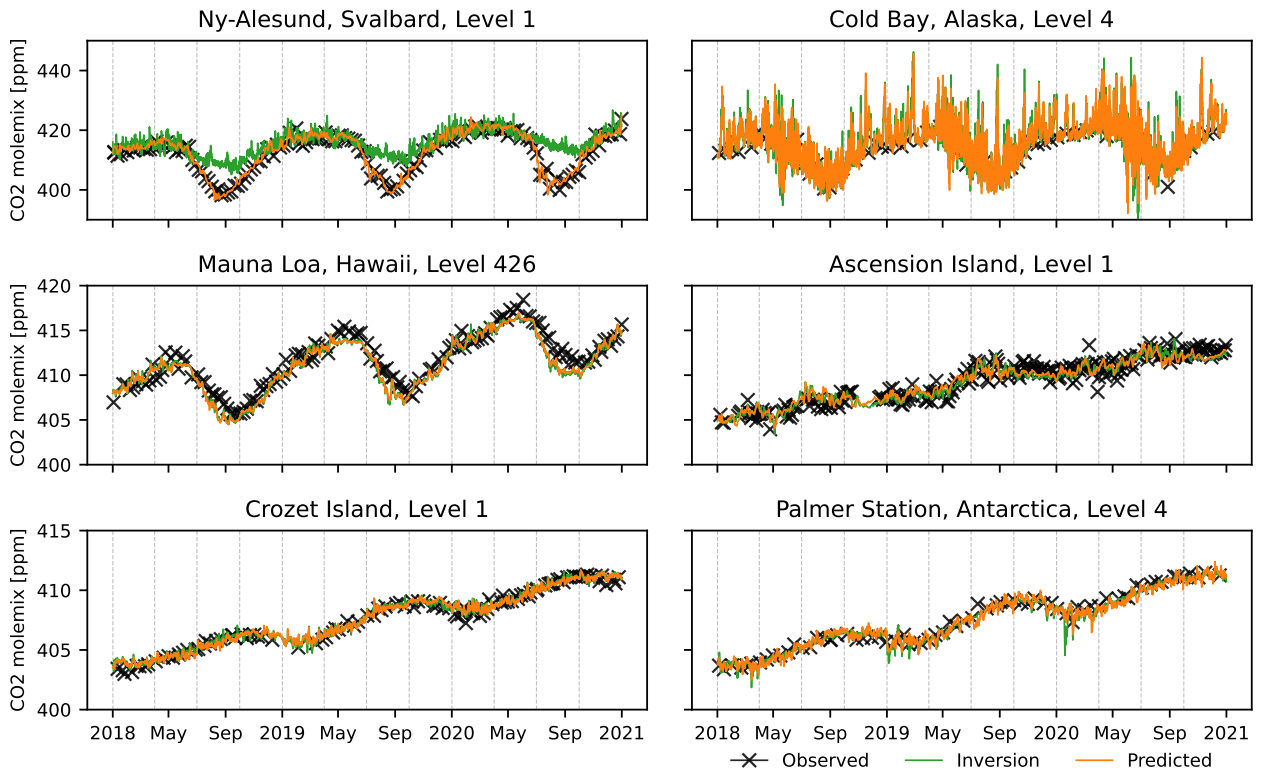


Figure S8. Same as fig. 6 but for UNet.



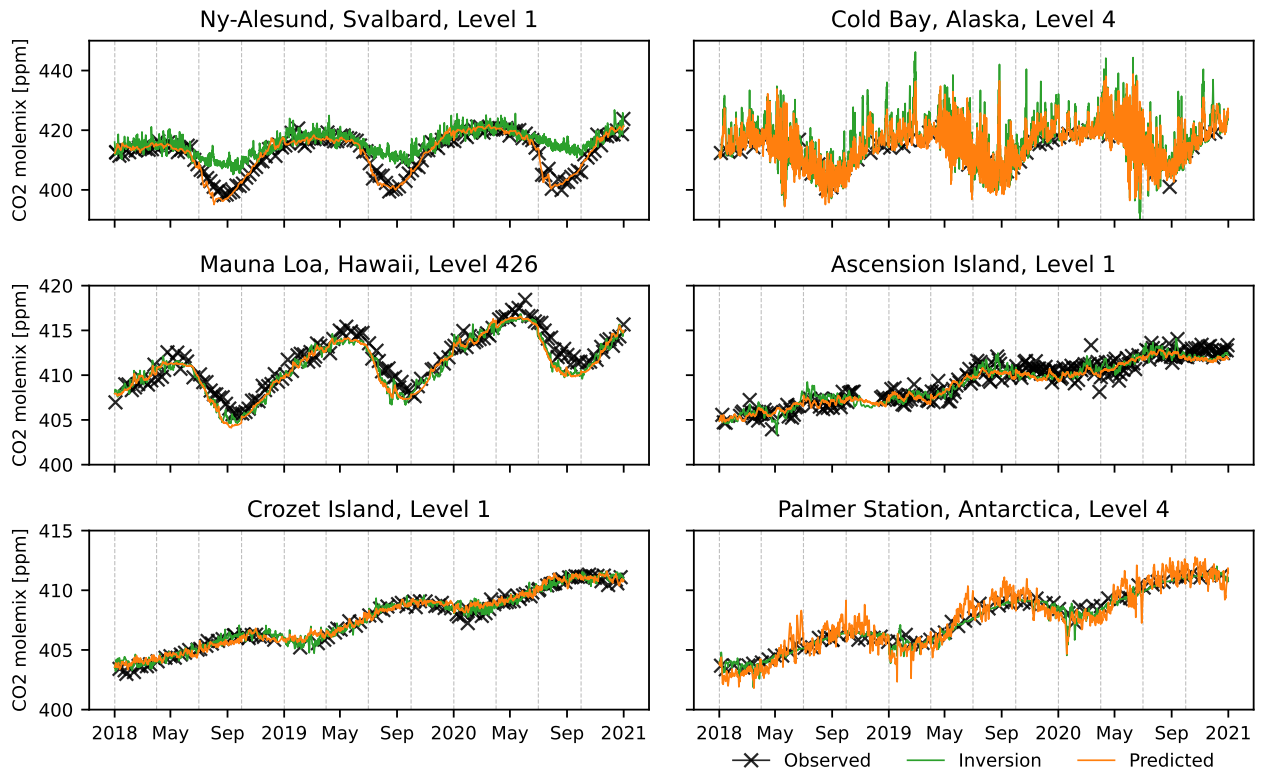


Figure S9. Same as fig. 6 but for GraphCast.

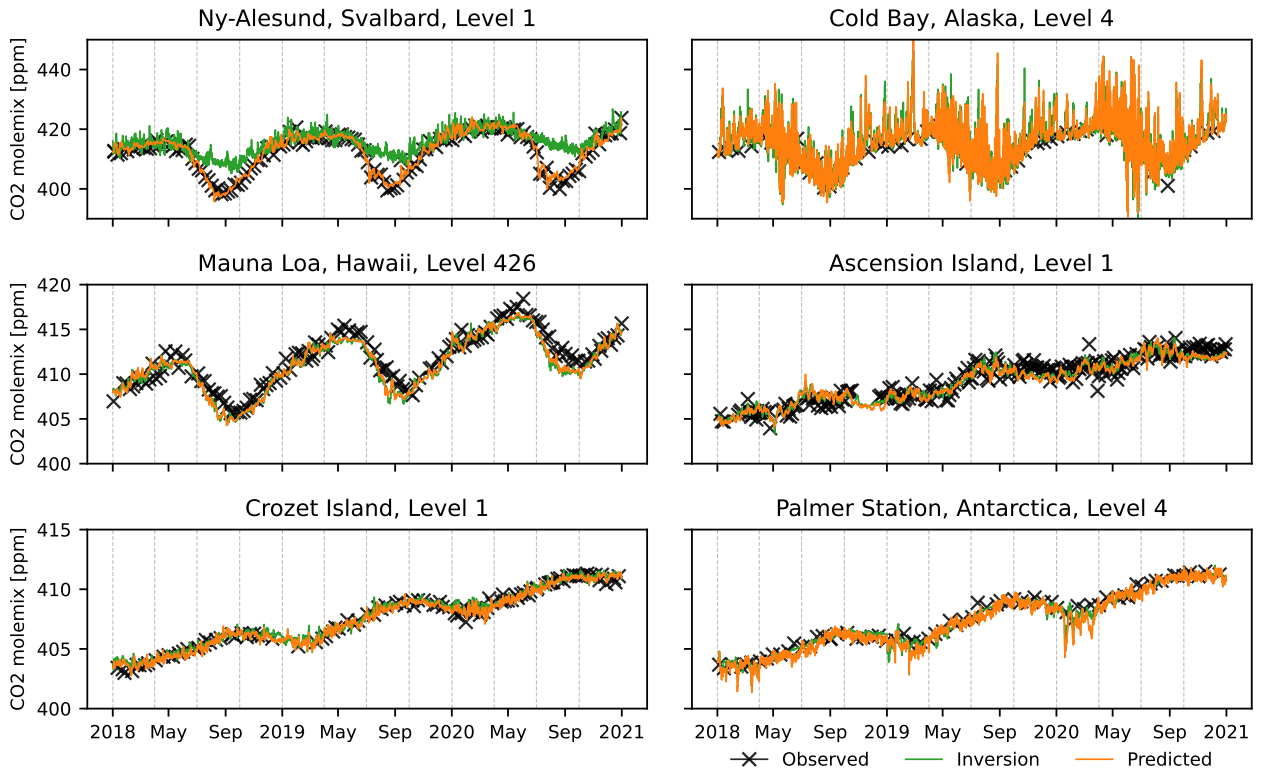


Figure S10. Same as fig. 6 but for SFNO.

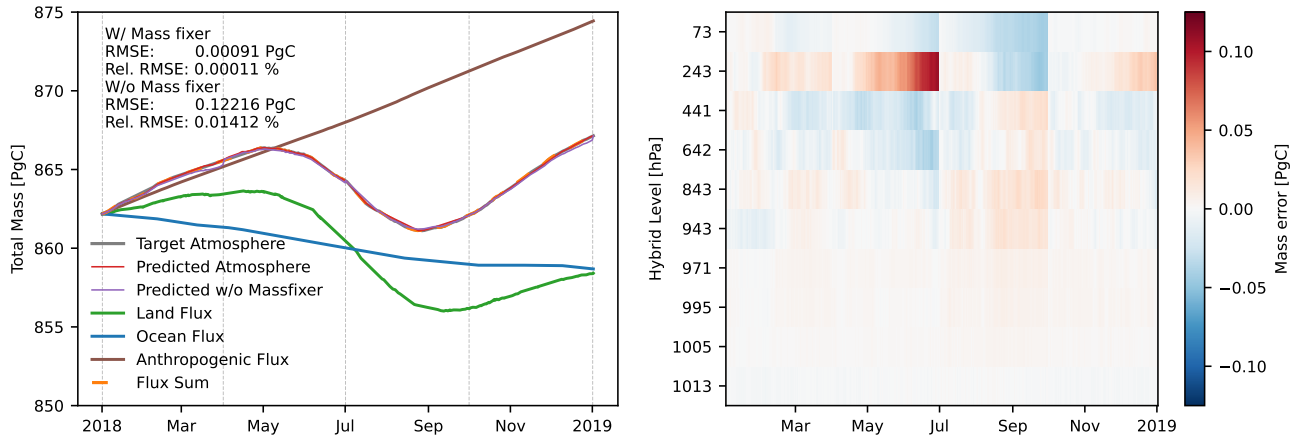


Figure S11. Same as fig. 7 but for UNet.

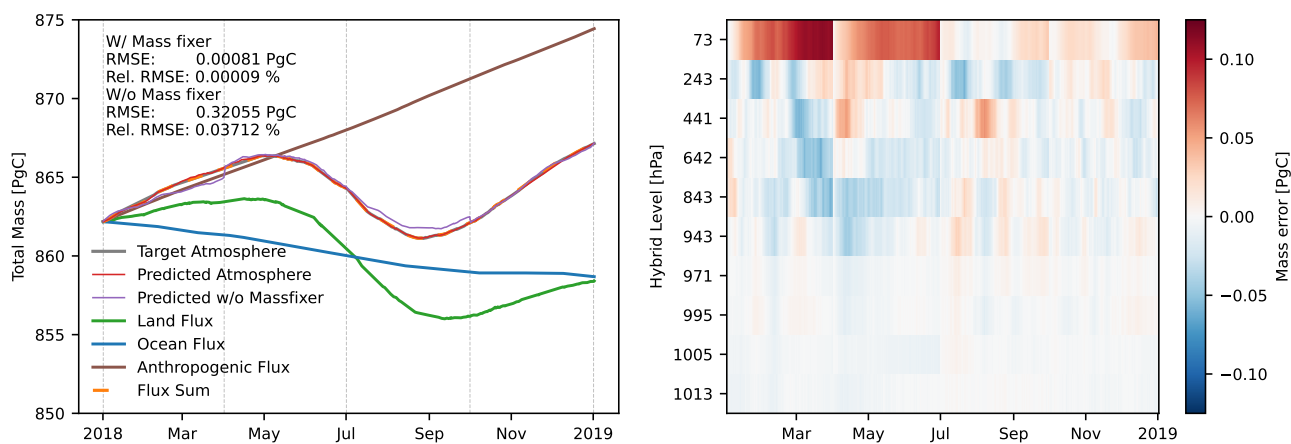


Figure S12. Same as fig. 7 but for GraphCast.

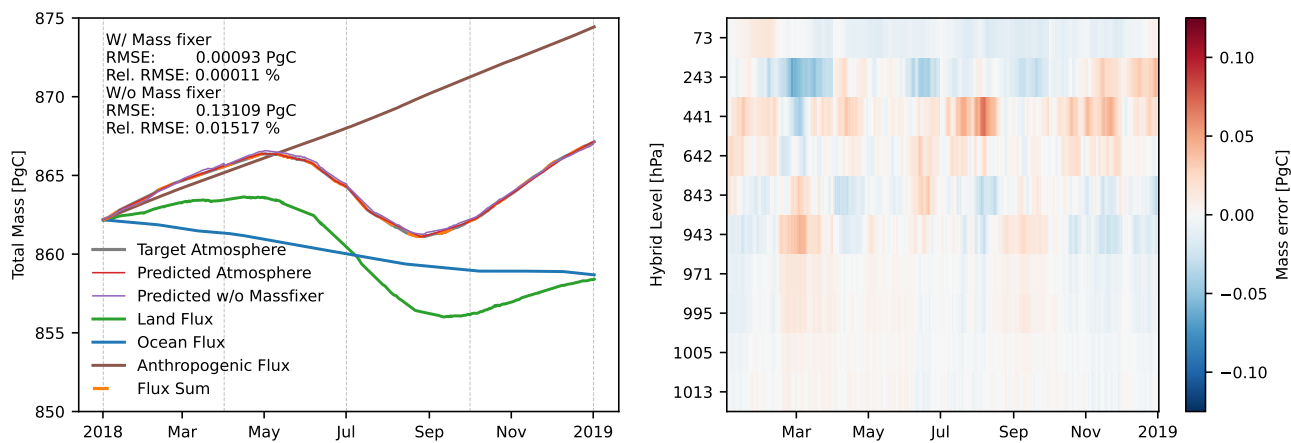


Figure S13. Same as fig. 7 but for SFNO.