Coupling of CarbonTracker with TM5/IFS

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Timeseries

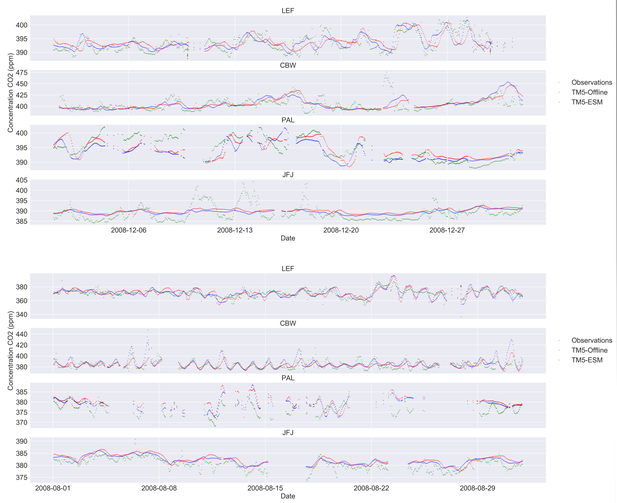


Figure 1: Timeseries of 4 observation towers for the winter (top) and the summer (bottom). Towers are Park Falls in the USA (LEF), Cabauw in the Netherlands (CBW), Pallas in Finland (PAL) and Junkfraujoch in Switzerland (JFJ). Both the synoptic and diurnal cycle are visible and they show good agreement between TM5-Offline (blue) and TM5-ESM (red) during the summer. During the winter the patterns are more chaotic, but there are no large disagreements

Problem Statement

The ultimate goal of the consortium is to use a fully coupled carbon-climate model to simulate the interaction between carbon and climate in different scenarios. The core of this coupled model is the combination of the models TM5 and IFS. In order to understand how accurate this combination is with the transport of CO_2, before dynamic carbon models such as LPJG and Pisces are introduced, the carbon fluxes of the CarbonTracker model are used as source and sink.

The first project of my PhD research focusses on the difference between TM5-MP forced with offline ERA-Interim meteo data (hereafter called TM5-offline) and the coupled IFS-TM5 model (called TM5-ESM).

Methods

Both models are kept as similar as possible, all the input and initial data are the same. The meteo data are different. TM5-offline uses ERA-Interim data, but TM5-ESM is nudged towards the ERA-Interim data of divergence, vorticity, temperature and surface pressure.

Since the CarbonTracker fluxes are optimised using the same meteo data as TM5-Offline during this run, it is expected that TM5-Offline will perform better in comparison to TM5-ESM

Runtime: 1 Januari 2008 to 31 December 2009
With 2 months spinup

Conclusion

All the results indicate that TM5-ESM gives similar results to TM5-Offline. The differences between the models are small and most likely caused by the small variations in metro-input.

Added value

- Provides proof of value for the coupling of TM5-IFS in the ESM
- Testing of the transportmodel of the future ESM in a controllable and verifiable environment

Next Steps

- Test the climatological skill of the model by turning the nudging off.
- Use LPJG and Pisces to calculate the carbon fluxes and reduce the need for carbon tracker
- Make the ESM interactive and more

Seasonal amplitude

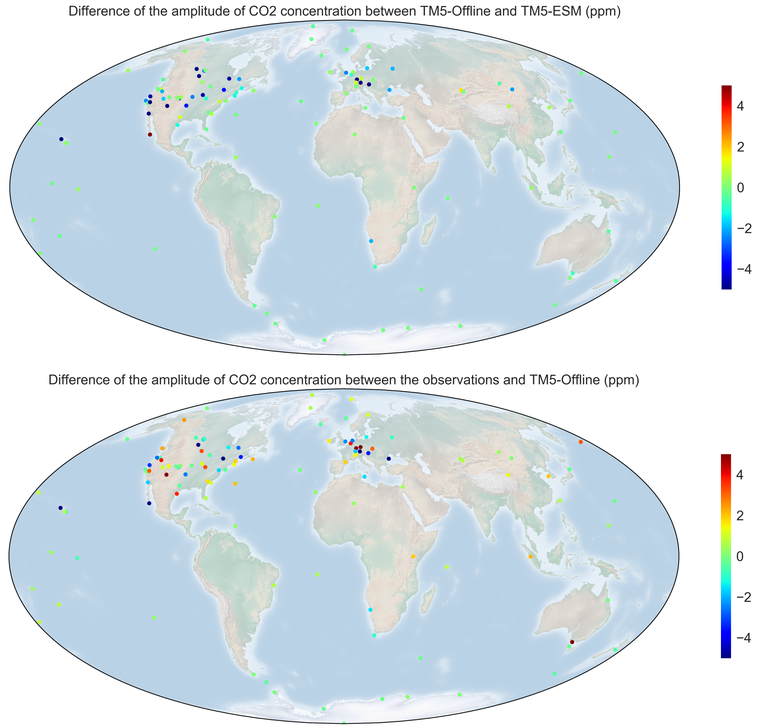


Figure 2: Seasonal amplitude difference calculated at NOAA observation towers. Difference between TM5-Offline and TM5-ESM (left) and Difference between Observations and TM5-Offline (right). The seasonal amplitude is calculated by the CCGcurve method for 2008 and 2009 and the mean is shown for the observation towers included in the NOAA obspack dataset. The majority of stations show a difference close to zero ppm, but for several stations the amplitude of TM5-ESM is larger than TM5-offline. Comparing TM5-offline to the observations shows that the bias between the model and the

Vertical mixing ratio

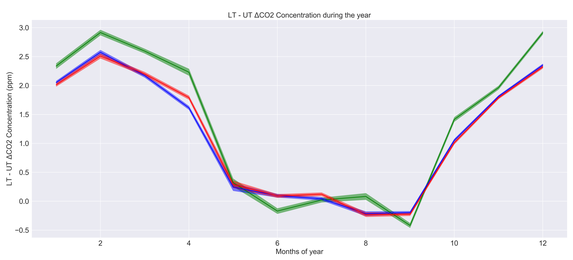


Figure 3: The global mean lower troposphere - upper troposphere concentration difference, with the standard error of the mean. Both models show the same trend as the observations, a large downward gradient during the summer on the Northern Hemisphere, when the vegetation grows and high and an upward gradient during the winter, when the carbon is released by the vegetation. Both models give the same results that mostly fall within the standard error bands of each other.

RMSE

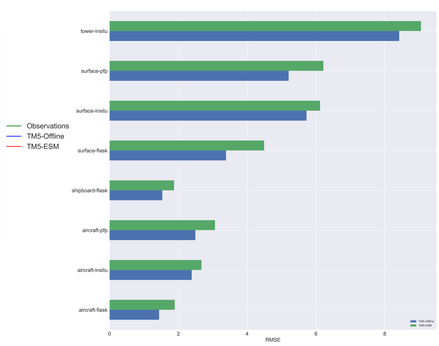
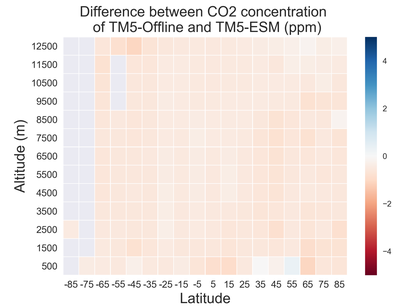


Figure 4: The root mean square error of the models for each different observation technique compared to the observations. This graph confirms the hypothesis that TM5-Offline would be closer to the observations. For each technique this is the case. However, the differences between the models are smaller than the differences between the models and the observations.

Latitude - altitude plots



Latitude - time plots

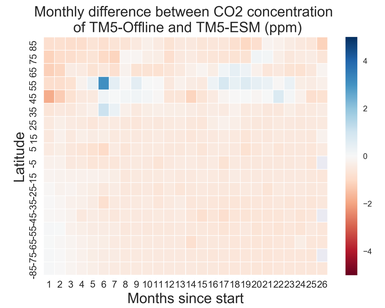


Figure 5: Top: Mean difference between TM5-Offline and TM5-ESM (ppm). Bottom: Mean Difference between TM5-Offline and the observations (ppm).
A cross section of the atmosphere shows that TM5-ESM simulates a higher CO_2 concentration than TM5-offline almost everywhere. This difference is on average 1 ppm, meaning that 0.5 Pg of carbon is extra in the atmosphere. The other model, TM5-offline, is also higher than the observations, but the difference between the models is smaller than the difference between the models and the observations.

Figure 6: Top: Monthly difference between TM5-Offline and TM5-ESM (ppm). Bottom: Monthly difference between TM5-Offline and the observations (ppm). The Northern Hemisphere the differences between TM5-ESM and TM5-offline are already close to 2 ppm in november 2007, one month after the start of the simulation. The stronger amplitude of TM5-ESM is also visible in this plot, as the situation is reversed during the summer and winter. On the Southern Hemisphere this amplitude difference is less strong and therefore not visible in this plot. The amplitude difference was stronger between TM5-offline and the observations and consequently this is visible in the plot.

Flux difference

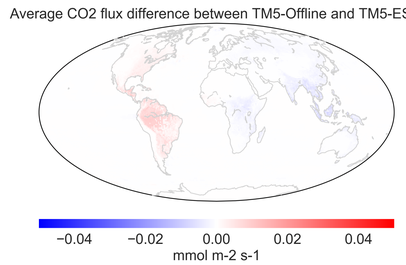


Figure 7: Average flux difference between TM5-Offline and TM5-ESM for the entire period. Each model has its own region where the flux is higher than the other model. TM5-Offline is higher in the Americas, while TM5-ESM is higher in Asia, Africa and over the oceans. The global average is positive, meaning that TM5-Offline has higher global CO_2 concentrations.

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