Regional Transport Analysis for Carbon Cycle Inversions

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1. INTRODUCTION

Working closely with colleagues at NOAA, we have obtained test data sets of hourly meteorological analyses generated by the Rapid Update Cycle (RUC) assimilation system on the 13-km grid over North America. We developed and tested subsetting software to extract only the transport fields from these analyses, and adapted the CSU Lagrangian Particle Dispersion Model (LPDM) to read the 13-km RUC fields. We have now verified that we can calculate adjoint, or backward-in-time, transport influence functions for specified sampling stations to quantify the sensitivity of each observation at NOAA sampling towers to unit surface fluxes of CO_2 or other trace gases at all points upstream in the RUC domain.

For each data point, i.e., tower location and sampling time (1 hour or longer), a separate influence function is derived which depends on spatial coordinates of source areas as well as release time of fluxes from the surface. Therefore, the RUC-LPDM system is generating a huge amount of data, which would be impractical to store and disseminate at full resolution for a year.

Figure 1 presents a series of influence functions [ppm/umol] calculated during testing the prototype RUC/LPDM system. They are derived for the 10-day period of March 6-16, 2006 and hypothetical 400 m towers spaced every 1000 km across the RUC domain. The influence functions are integrated with unit CO_2 flux from the surface (1 umol/m^2/s). In a similar manner the influence functions can be derived for all active NOAA towers (or any other locations of interest) and can be integrated with the user provided CO_2 fluxes instead of the unit flux.

2. DATA COMPRESSION AND STORAGE

We have investigated several methods of aggressive data compression to solve this problem. It would be possible and perhaps advisable to convolve the transport influence functions with a surface flux model (such as SiB, which we use at CSU), and integrate over longer periods of time. We have shown that compression of the order of a factor of 100 is possible by this method, which assumes that high-frequency (hourly to daily) variations in surface fluxes are well-captured by the model and that the influence functions would be used to correct the model on time scales of several days. We will apply this approach at CSU/CIRA, but recognize that other users of the influence functions may prefer to use the product at full temporal resolution or apply their own models to the compression and flux inversion problem.

To compromise between the need for data compression and flexibility in applying flux models to the influence functions, we have designed the storage and dissemination system to store Lagrangian particle positions rather than integrated influence functions. The advantage with respect to storage is the, unlike for the case of gridded integrated influence functions, only locations that influence a particular measurement are stored. The system will therefore need to integrate influence functions "on the fly," at the time that the product is disseminated. The system will offer influence functions convolved with hourly SiB fluxes and deliver vastly compressed data, or to send the gridded functions at full resolution for shorter periods. This approach involves a necessary trade off in increased computational cost in the data system to achieve disk storage savings.

3. CURRENT INVESTIGATIONS

We are currently investigating different approaches for mass-adjustment of the RUC wind fields before they are used in the LPDM. We have also begun work on a new scheme in the LPDM model for subgrid-scale vertical transport associated with parameterized cloud mass fluxes due to cumulus clouds. This work will continue in year 2 of the project during which we will complete the system, and build and deploy a web interface for delivery of the product to other researchers.

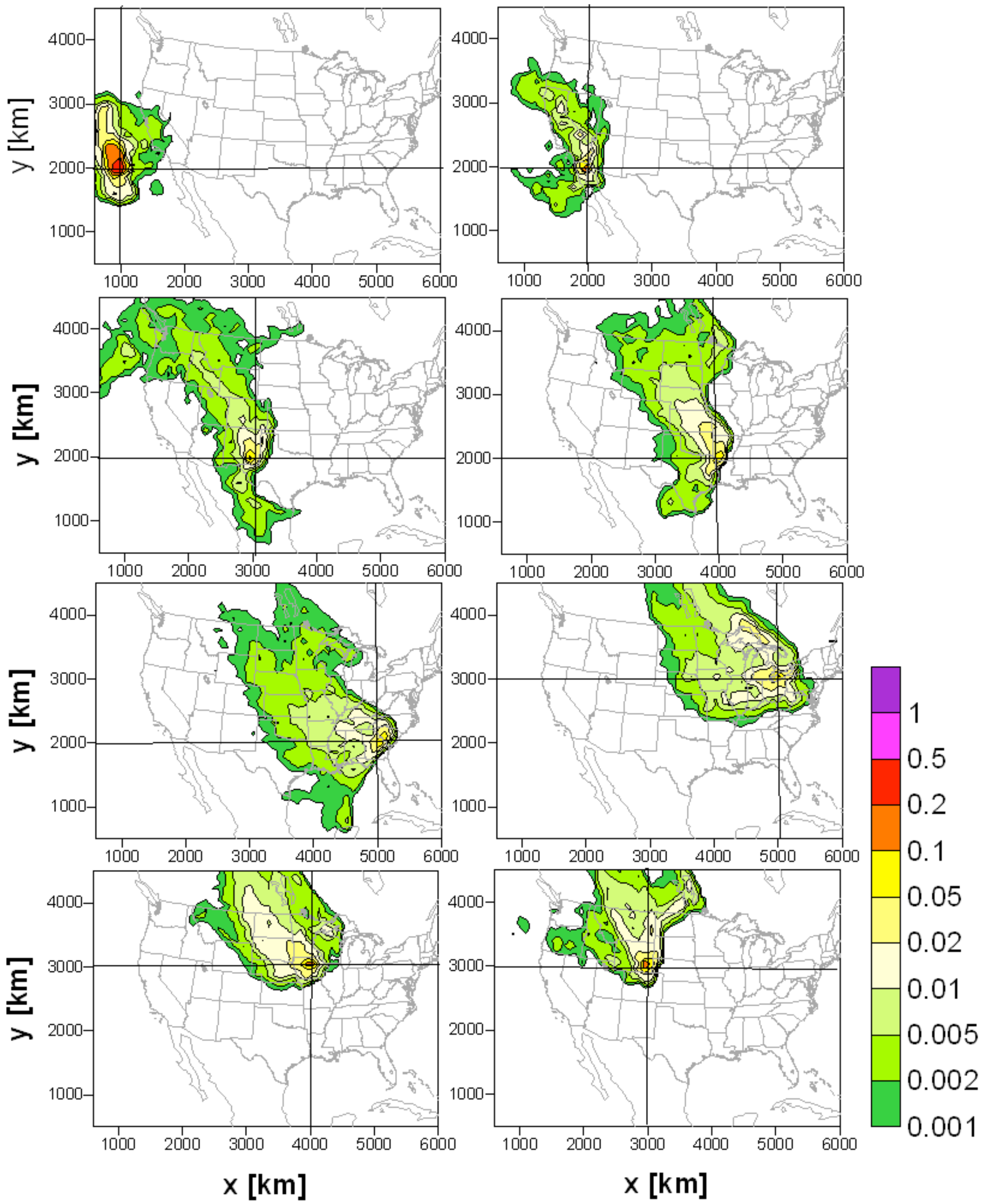

Figure 1. Examples of influence functions [ppm/umol] derived with the RUC/LPDM system for the 10-day sampling period of March 6-16, 2005 for a series of hypothetical 400 m towers spaced across the RUC domain. Each influence function describes the contribution of the flux of CO_2, or other trace gas, released from the surface within the tower footprint into the concentration observed at that tower during the sampling period.

Abbreviations:

CIRA	Cooperative Institute for Research in the Atmosphere
CSU	Colorado State University
LPDM	Lagrangian Particle Dispersion Model
ppm	Parts per million
RUC	Rapid Update Cycle
SiB	Simple Biosphere Model
umol	micro mol