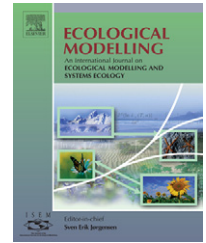


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A nonparametric algorithm to model movement between polygon subdomains in a spatially explicit ecosystem model

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ABSTRACT

Many modern spatially explicit ecosystem models use modelling subdomains of different shape and size ('polygons') to resolve space, and movement of biomass between them forms an important part of the modelling effort. In marine applications, a flow field grid describing the water movement usually forms the basis for movement of passive or nearly passive biomass. Grid-based advection algorithms are not designed to model movement on the larger scale of polygons, resulting in disproportionately large computational costs and difficult communication between model layers. In this paper, a simple and effective algorithm to model movement at the polygon level is proposed, preserving the general properties of biomass distribution in comparison to a grid-scale model.

A nonparametric description of inter-polygon movement in the domain is generated which is used to approximately replicate the observed movement pattern. To estimate the movement description, the moves of passive numerical drifters between polygons are observed. The resulting algorithm outperforms the conventional polygon-based transport equation approach both in artificial and realistic scenarios.

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1. Introduction

1.1. Application areas for movement algorithms

In recent years, most newly developed large-scale ecosystem models include a spatial component, although spatial resolution is usually constrained both by computational costs and limited knowledge about fine-scale processes. Marine food web models typically need to use large boxes or polygons to appropriately capture population processes, rather than trying to impose these processes on a grid (Constable, 2005a, b). This very flexible approach allows us to scale the model to the exact amount of detail supported by the available data.

A Southern Ocean marine ecosystem model of this type is currently under development at the Antarctic Climate and

Ecosystem Cooperative Research Centre (ACE CRC) and the Australian Antarctic Division (AAD). In this context, Constable and Nicol (2002) have proposed criteria for management areas in the Southern Ocean, which might also be used as modelling subdomains. When fully developed, the model will be used to assess the impact of issues such as climate change, over-exploitation, conservation procedures and harvesting strategies on the Southern Ocean ecosystems. Due to its central role in most Southern Ocean food webs, particular emphasis will be placed on the modelling of krill. Although krill is known to migrate vertically, it is assumed that its horizontal movement is primarily influenced by ocean currents, rendering it a nearly passive biomass. Therefore, the movement of nearly passive biomass forms an important part of the ecosystem model, providing the motivation for this paper.

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However, the method developed below is not restricted to the envisioned application, but can be useful in any spatial large-scale ecosystem model (e.g. Zeller and Reinert, 2004).

As an example, let us consider biomass originating from an island in a laminar flow field (Fig. 1). The modelling area is represented by four polygons, one describing the immediate

surroundings of the island, one the larger area around the island and the other two areas further downstream, and an aggregation of biomass progresses through them. Having set up the polygons, the modeller is interested only in the amount of biomass per polygon – as indicated on the right of Fig. 1– while the exact spatial distribution is not so important.

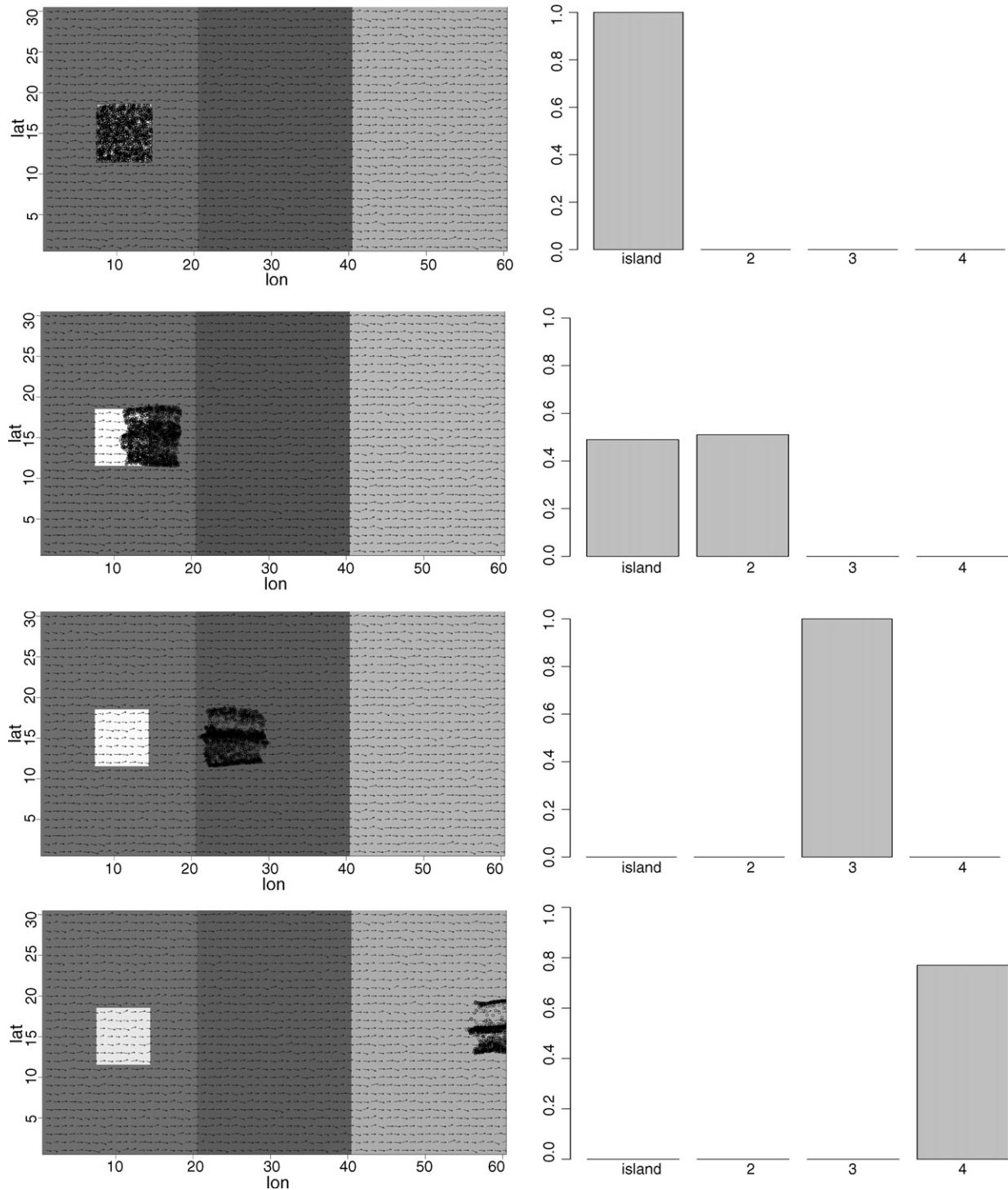


Fig. 1 – Biomass moving through polygons. The island on the left and the three differently shaded areas constitute polygons, while each arrow corresponds to a grid cell. An aggregation of biomass leaves the island inside the left polygon and moves with the flow. For the purpose of a polygon-based model, the density per polygon given in the barplots on the right is sufficient.

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