Braided river evolution and bifurcation dynamics during floods and low flow in the Jamuna River

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River and delta morphodynamics

Background

River bifurcations are critical elements in many channel systems (e.g. braided rivers). They control the partitioning of water and sediment with consequences for the downstream evolution and for river and coastal management.

Introduction

- River pattern research focuses on discrimination of different types and physical explanation.
- A braided river consists of many parallel channels, bifurcations and confluences.
- Bifurcations are inherently instable and become more and more asymmetrical.

Hypothesis

- The braidingness of a river decreases during steady flow due to bifurcation asymmetry and therefore the formation of dominant channels.
- The braidingness increases after flooding due to the formation of new bifurcations and the reset of bifurcation asymmetry.

Required

- A dataset of all channels and nodes at different dates.
- This dataset needs a network topology.
- Datasets at different dates need to be linked in order to analyse the evolution of the river.

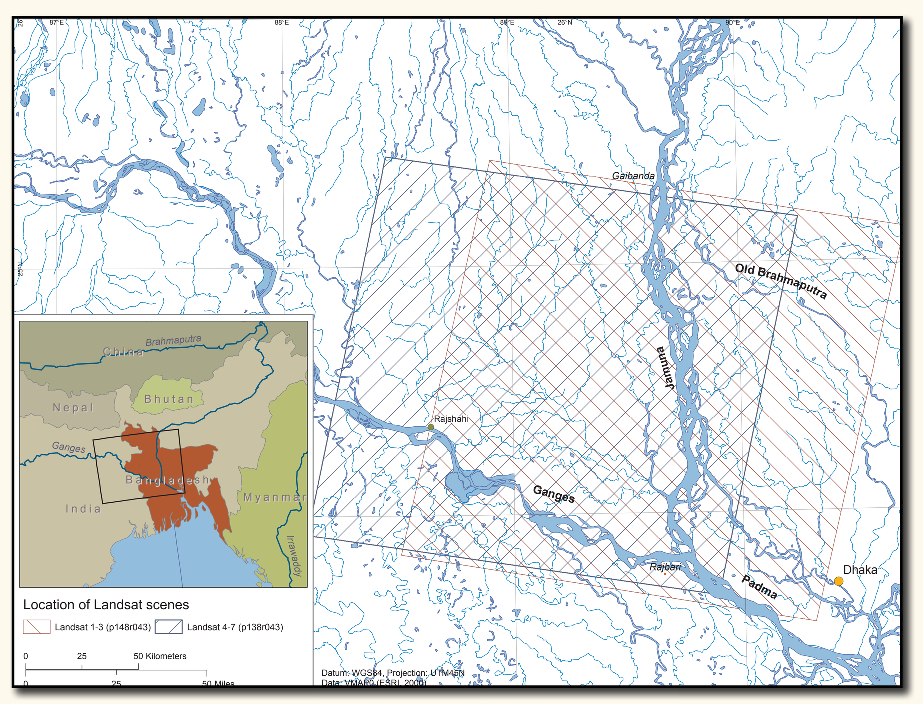

Figure 1 *Research area*

Methods

- Available data: 13 Landsat images, 1999 - 2004.
- Channel network extraction (see box)
- Brain Connectivity Toolbox (BCT)[1], toolbox capable of calculating various network measures.
- Analysis of the network:
  - Network measures using BCT,
  - Bifurcation asymmetry based on width,
  - Bifurcation asymmetry development for linked bifurcation,
  - Braiding Index (BI) (number of parallel channels),
  - Weighted BI (number of parallel dominant channels), derived from centrality network measure - which indicates the importance of all elements in the network.

Channel network extraction

- Channel centre pixels and centrelines from a classified image (fig. 2),
- Channel width from the distance to the nearest bank,
- Standard vector topology is transformed to a network topology, denoting the connected elements for all nodes (fig. 3).
- Nodes in datasets at different dates are linked based on distance and configuration of connected channels.

More on these methods:
Addink et al.: H41K-03, Thursday 8 am

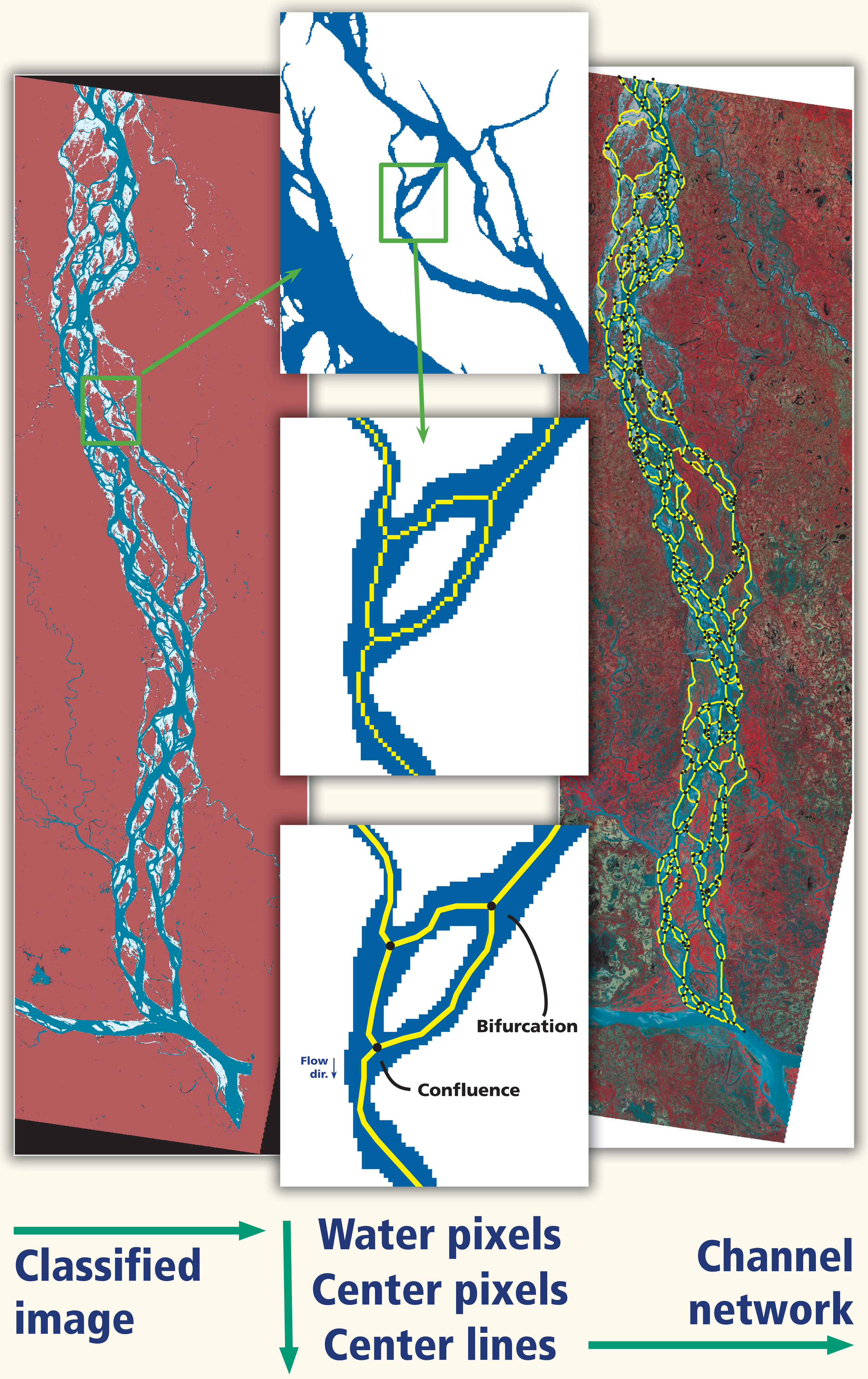

Figure 2 *River network extraction from a satellite image*

Bifurcation dynamics

- Bifurcation asymmetry based on width asymmetry at all bifurcations in the network
- Bifurcation asymmetry development for all linked bifurcations in consecutive scenes

Examples

- Increasing bifurcation asymmetry after low steady flow period (fig. 3)
  - This corresponds with dominant channel formation (fig. 6)

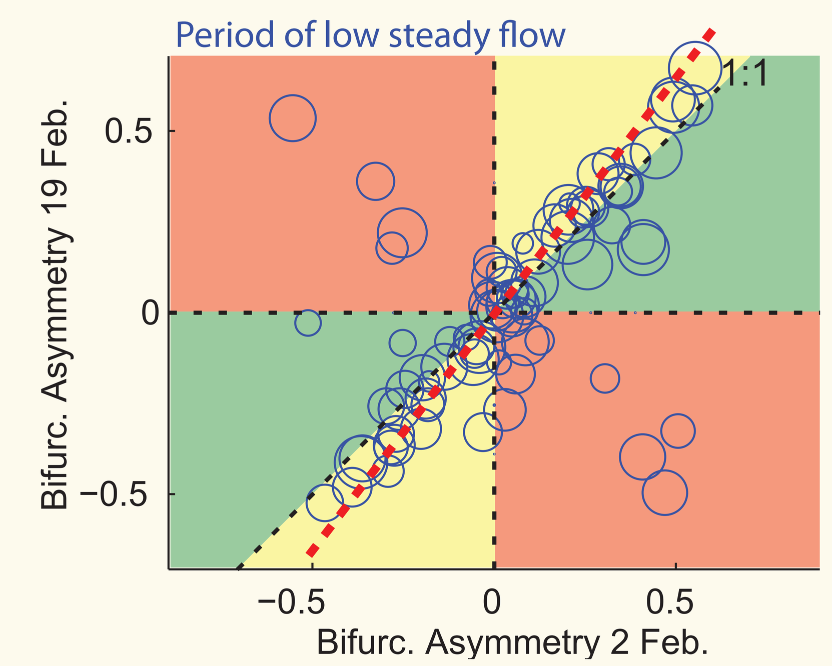

Figure 3 *Bifurcation asymmetry development during a period of low steady flow.*

- Chaotic after flood: new channel configuration / bifurcation asymmetry-reset (fig. 4)
  - This corresponds with increased river braiding (fig. 6)

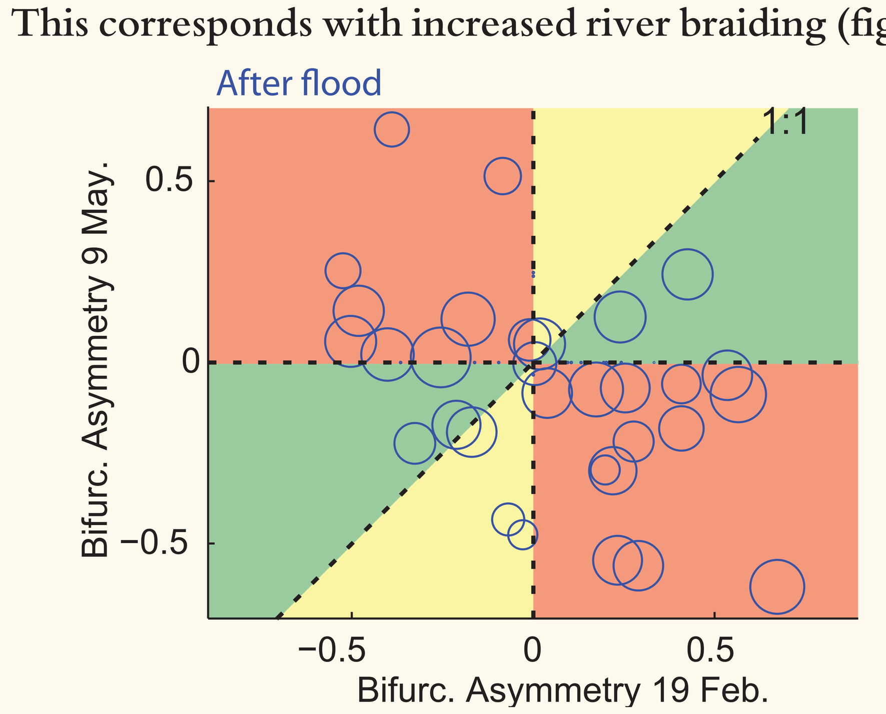

Figure 4 *Bifurcation asymmetry development as result of flood*

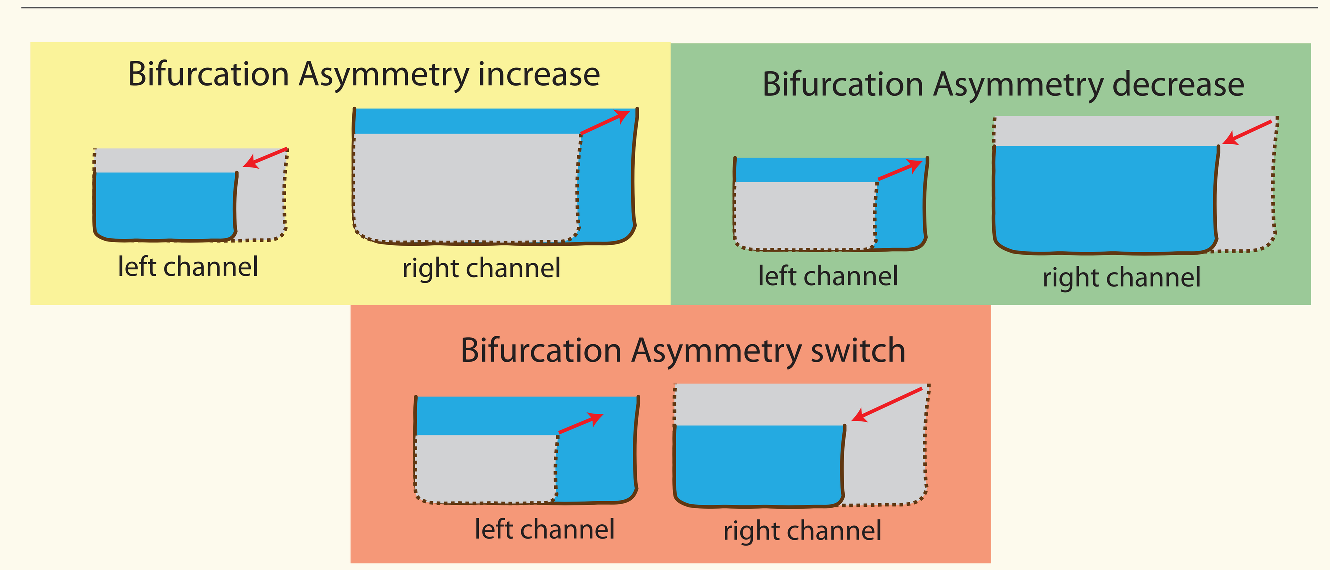

Figure 5 *Legend to Figs. 3 & 4, different areas denote different development*

Braiding development and dominant channel formation

- Braiding Index (BI): number of parallel channels,
- weighted Braiding Index (wBI): number of important channels

Seasonal variation (fig. 6)

- Decreasing number of parallel channels (BI) during steady flow
- More parallel channels after flood

No active braiding in dry season

- Number of parallel channels (BI) > 4,
- but number of dominant channels (wBI) < 2 at end of dry season:
  - Strong dominant channel formation,
  - Hardly any active braiding

More big river dynamics: Gupta et al.: EP24B-06, Thu. 6 pm

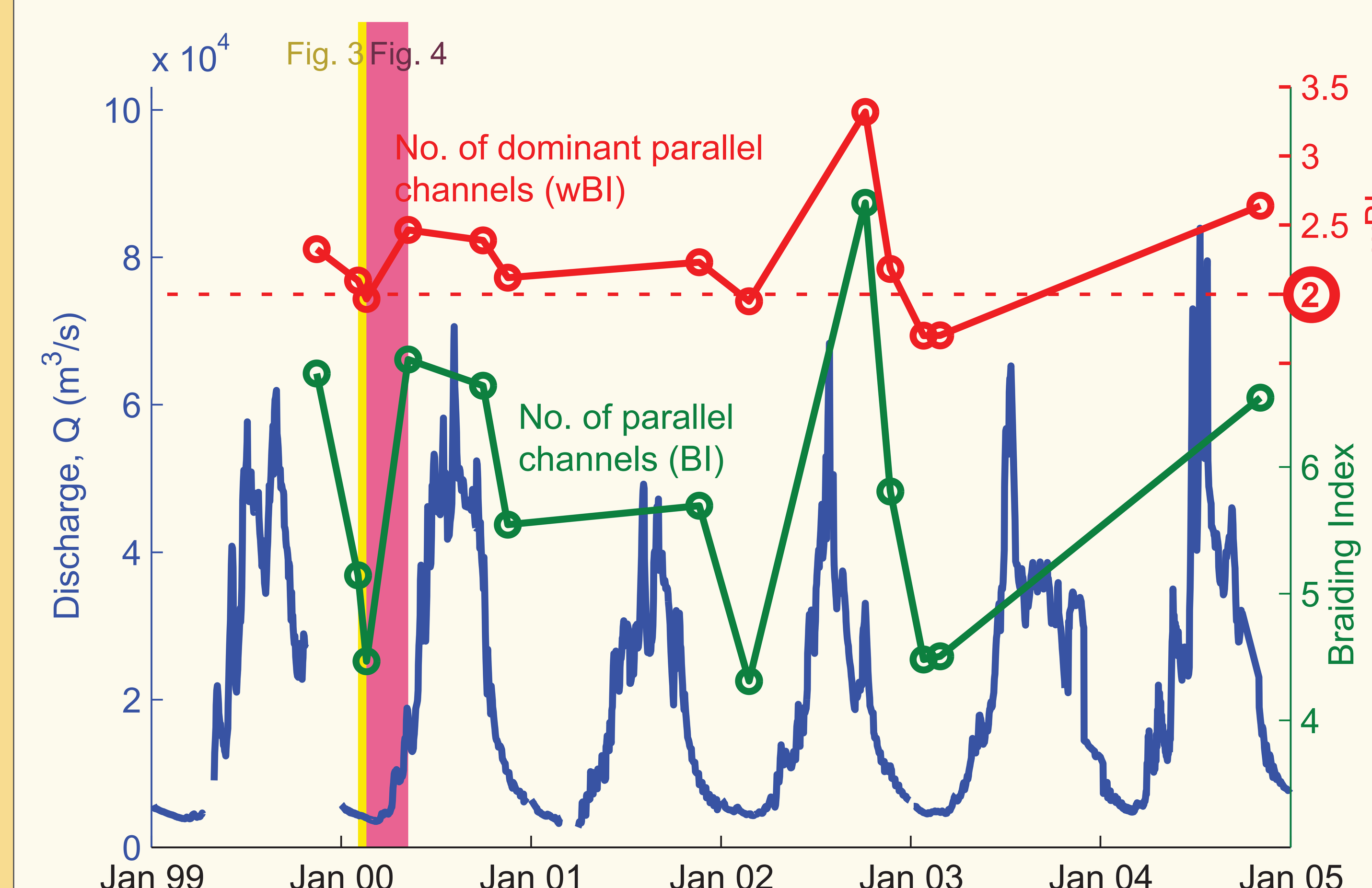

Figure 6 *Development of Braiding Index (BI, no. of parallel channels) and weighted BI (no. of important / dominant parallel channels)*

Conclusions

- Dynamic channel network extraction is a powerful tool for river network analysis
- Low steady flow: decreased braidingness
  - Bifurcation asymmetry increase, some bifurcate closures,
  - Less parallel channels and more dominant channels.
- Flood: increased braidingness
  - Bifurcation asymmetry resets and formation of new bifurcations,
  - More parallel channels and less dominant channels.

References 1) Rubinov, M., and O. Sporns (2009), Complex network measures of brain connectivity: Uses and interpretation, NeuroImage, doi:10.1016/j.neuroimage.2009.10.003.