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PLURAL TERRITORIAL INTEGRATION AND ROAD NETWORK CONFIGURATION IN SOUTH AMERICA

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ABSTRACT

The subject of integration between national territories in South America became urgent after the creation of MERCOSUR economic block in 1991, what gave rise to several transnational cooperation projects. The original associates -Argentina, Brazil, Paraguay and Uruguay - have been sharing robust historical cross border exchanges. Following global trade trends and focusing on the opening of Eastern markets for South American goods. Oceanic connections became vital in reducing transportation costs, intensifying cargo flows along routes linking production poles to seaports. Diminishing export costs is priority to all South American national states, therefore the improvement of infrastructure systems connectivity and cooperative planning strategies are now priorities in order to turn the Block competitive in global markets. Cargo traffic through South American road network at regional level is prevalent, since territorial planning coincided with the diffusion of motor vehicles industry expansion from 1950 on, following different patterns of integration at national scale, diversifying relations between borders and political centers and morphological differences on each system separately. Our objective in this paper is to describe road networks configurational differences for each South American country in order to depict their potential centralities and analyze changes emerging from regional subsets defined by cooperative projects. Our hypothesis is that national road networks centrality hierarchies are modified at regional scale, hence related to structural changes on cross continental accessibility and connectivity. The methods applied to depict South American road network structure combine data collected from national transport databanks gathered on a GIS platform where road centre lines were captured, revised, simplified and generalized. Following Space Syntax methods, national, regional and continental road networks were modeled with *Depthmap x 0.5* appliance that enabled axial and angular multi-scale analysis of integration and choice measures. Analyses performed evidence changes on national goals towards endogenous and exogenous patterns of spatial integration. Results display road networks centrality hierarchies underlying cross-border flows probability at local scale, corroborating strategic shifts on regional integration patterns and cooperation policies along South America recent history.

KEYWORDS

MERCOSUR, South America territories, road network multi-scale configuration, cross border integration

1. INTRODUCTION

According to early 20th century geographers like *Vallaux* (1928), it is important to differentiate the notions of limits and territorial borderlines, since the last one incorporates the idea of frontier as a peripheral and dynamic device, subjected to the strength of neighboring national societies. Nowadays, cross-border flows recall these notions in, revising them under the spell of multidimensional integration and regional cooperation that detach economic frontiers from territorial limits, giving emergency to jurisdictional borderline zones issues in the political agenda.

Integration improvement between South America national states became urgent after the creation of MERCOSUR (1991) economic block in 1991. Despite their divergences towards integration expectations at local and national spheres, cross-border exchanges date back to colonial times, when economic and social relations at frontier zones subverted the ones imposed by European Colonial powers. This frontier zone context is most noticeable within the influence area of South America geographic core - the La Plata River Basin -, which encompasses 18% of actual national territories as follows: Paraguay100%, Uruguay 79%, Argentina 34%; Bolivia and Brazil +-17% (Vilella, 1984; OEA, 2005). Territorial disputes imposed peculiarities to its occupation process and the endurance of cross-border relations between neighboring countries at local scale (Braga et al. 2016).

The "regional approach" to long lasting frontier zone practices are based on cooperation projects that regulate robust historical cross border exchanges in order to improve their efficiency and contain their negative outcome , what is not exempt of conflicts, revealing the unevenness of power between transnational institutions' members, where MERCOSUR founders and signatories of the 1st La Plata Basin Agreement (Brasília, 1969) prevail over other national states. Unevenness in population size, economic dynamics and resources mediate planning strategies for which transnational and cross-border relations reorganize endogenous infrastructure networks, in order to accomplish shared goals towards South American commodities competitiveness improvement. In most cases, institutional and political interests orbit around transportation efficiency and economic and functional resources strengthening, while preserving national state territories' cohesion (Bender, 20??).

A regional space is defined by sets of subspaces whose multidimensional and multiscale interactions grant discontinuities within discrete spatial systems, such as urban and road networks. Complex systems definition as "a set of elements related to each other, which interactions' structure depict tendencies or bifurcations on the system self-organization" (Aschan-Legonye, 1999) address heterogeneity and as the main property informing spatial organization: "if geographical space is considered as a set of interacting elements, spatial structure must be understood as the organizing principle of the geographical entity under study, which is materialized under a form (axis, pole, etc)". (Elissalde, 2004). Therefore, circulation networks continuity across territorial limits encompassing whole continents, change flows intensity and their direction, modifying urban networks hierarchies at regional scale, that update polarization processes and the recurrence of economic and functional activities at local scale.

Such problem requires multiscale analysis to depict phenomena related to spatial networks structuring logics rather than territorial ones. As appointed by Milton Santos (2006, p.188), "the expansion, superposition and integration of different networks at global scale are changing networks' spatial limits, and modifying polarizations, therefore giving emergency to new territorial orderings". From that we drew our objective, which is to describe and analyze the spatial configuration of each national urban network and their changes emerging from planning strategies imposed by transnational projects in South America that are informed by the opening of new markets (Asia+ Africa, 53% Brazil gross exports: Russo *et al*, 2007) for South American commodities, what modified cross-border flows (Wilmsmeyer; Sanchez, 2009). UNASUR (South American Nations Union, 2015) supranational projects target to improve complex interactions beyond state control, through strategic territorial planning tools managed by COSIPLAN (South American Council on Infrastructure and Planning) and IIRSA (Initiative for Integrating South America Regional Infrastructure, 2012). One of such tools draw from the notion of development corridors as "spatial cutoffs encompassing urban network main hubs and demographic or economic concentrations along a trading route" (Bender, 20??), to improve infrastructure systems connectivity at continental scale along project axes, the urban network's nodes to their surrounding territory; and to promote multimodal integration through logistic hubs. Their targets are "to improve connections in networked spaces with different topological depths across national territories" (Fau et al, 2016), what tend to modify infrastructure networks topology, producing hierarchical changes in urban networks at continental scale (Figure 1).

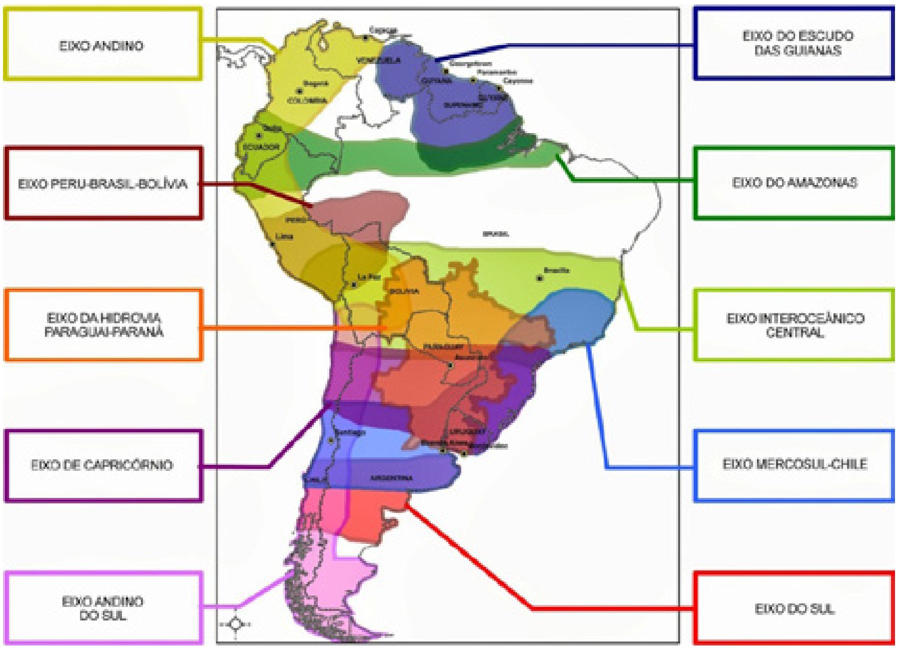


Figure 1.- South America: Integration and Development Axes. Source: IIRSA, 2012 URL: http://www.geosur.info/geosur/iirsa/pdf/es/ejes.jpg

The notion underlying this research problem and its analytical scale is that of urban networks as self-organizing systems, which structures are codependent to the circulation and transportation ones. Therefore, it is expected that if their continuity and connectivity patterns are modified through uneven fusion processes across territorial borders, then hierarchical changes will occur at regional scale, impacting borderline gateways that acquire new significance towards local and regional integration patterns.

Our hypothesis is that national road networks centrality hierarchies are modified at different scales, hence related to configuration changes imposed by cross continental accessibility on regional subsets or spaces. This approach attests the efficacy of Space Syntax methods and tools in providing a systemic analysis of multiscale change processes emerging from different territorial framings imposed upon South America urban network, that relate to polarization processes at regional and national scales. The case study reiterates research findings conducted by Turner (2007), Serra et al. (2012) and Hanna et al. (2013), validating its appliance in regional studies.

2. DATASETS AND METHODS

According to PUMAIN (2004) a configuration underlies the production of every spatial organization. Spatial configuration analysis enables descriptions of multiscale changes in interactions between territorial planning goals at national scale, and new forms of spatial organization based on economic integration at regional scale, to depict the morphological variables enacting hierarchical changes within urban networks. and give emergency to complex phenomena at regional scale such as polarization and functional specialization.

SERRA et al. (2015) state that "a GIS network representation of road-centre-lines, when analyzed by space syntax topo-geometric centrality measures, could emulate the syntactic segment representation derived from axial lines". Such network models enable the identification of qualitative and quantitative form-function asymmetries emerging from polarization processes, conceptualized as "the attraction exerted by one place over heterogeneous space, proportional to regional agglomerate development, described through different urban networks centrality measures" (Elissalde; Saint-Julien, 2004).

Road networks topo-geometric structures combined into different subsets depict multiscale relations and interchanges informing regional disparities and tendencies for hierarchical changes that enable to analyze spatial integration asymmetries between Brazil and its South American neighbors. If both are functions of multiscale centrality measures of circulation networks as pointed by Turner (2007), Hanna et al (2013) and Serra et al. (2014), testing limits for road networks is a methodological exercise that might unveil peculiarities related to these networks continuity across territorial borders, and depict subsets' changes that modify local development tendencies.

The segment models put together to perform the proposed analysis were firstly based on road-centre lines, depicted from available GIS database (Open Street Map, 2014; IIRSA, 2016). This method proved itself problematic for the following reasons: a) network connectivity failures and incompleteness of road networks on the selected geographic scale (1:5.000.000) due to differences in geometry and density of each country road network and geographic constraints in territorial occupation patterns; b) differences in roads features categories that turned unviable the modeling of such graphs without imposing some generalization and simplification rules to the base that implied in a complementary segmentation process.

According to Jiang & Claramunt (2002, a/b) and Mackaness et al. (2007), linear objects (streets, roads) generalisation rules target to retain the network basic geometric, topological and semantic properties. It consists of data filtering and geometry simplification, in order to reduce the road network complexity, while retaining its spatial structure. Therefore, features and attributes of road categories were homogenized and grouped, complying with reduced scale parameters. Graphic generalisation consisted in simplifying geometric features, retaining the network spatial structure. The authors suggest that linear representation of generalisation procedures is a cartographic ordering process, which routines preserve the network main characteristics, being context dependent.

Procedures incorporate "perceptual grouping" to reduce the network detail level, preserving its connectivity, interdependencies and linkages with other contextual data such as political boundaries. Perceptual grouping is a phenomenon through which human visual system spontaneously depicts elements of visual fields and groups them according to their features, such as continuity. It enables to infer information on relations (Mackaness et al, 2007, p.260) and retain geometrical and structural detail -*strokes*-. In line simplification routines, it allows the removal of whole strokes, without compromising the network generic geometric properties. Therefore, segment length and connection type ("T" - representing dead end country roads) were suppressed i diminishing irrelevant information and the network size in number of segments. Vector simplification consisted in fusing segments ≤ 2m in road turns segmentation. Therefore, semantic (road type) and geometric (segment length) data were simplified, resulting in a graph that preserved the network topology consistent with both, axial and segment maps, proposed by Space Syntax methodologies. As stated by Mackaness (*idem*) "the associate segment geometry could be represented by a *poliline* structure, weighted according to different properties, in order to obtain the network shortest paths, preserving its topological characteristics such as adjacency and connectivity", providing a controlled generalization. The same simplification and generalization rules were applied on each national state transport authority map - either shape files or raster images (Chart 1) - to homogenize discrepant features - roads classes and geometric detailing, indispensable to perform angular analysis at continental scale. Routines applied: a) grouping of roads types into a single vector layer since national classifications met no equivalence among themselves; b) suppression of features (strokes) in order to minimize the number of segments in each subset; c) compose multiple geo-referenced assemblages of continental, national and regional subsets on the database. Geometric distortions were corrected applying *Rubbersheeting* (©ArcGIS 10.1 Pro; Arcmap) to adjust raster bases after converted to planar projection - WGS 1984 Web Mercator to regroup each national map into *Open Street Map* database, enabling the analyses on Depthmap x 0.5 (Varoudis, 2013) as seen in Figure 2.

National State	Territorial area / km2	Terrestrial Borders/ km	Road network/ km	Source SIG Data bank / raster image
Brazil	8.515.767,049	15.735	1.751,000	DNIT - Transport Infrastructure State Department - VGEO Atlas multimodalhttp://www.dnit.gov.br/planejamento/dnit-geo
Argentina	3.761.274	9,665	231,374	Plano de Carreteras y Caminos en Argentina http://www.aca.org.ar/servicios/cartografia/republica_argentina.html
Uruguay	176,215	1,564	30,331	http://www.mtop.gub.uy/documents/20182/21207/mapasMapa+dnv.pdf/60b8cd22-430b-439f-a797-568d659e76e3
Paraguay	406,752	3,920	73,929	Gobierno Nacional de Paraguay - Ministerio de Obras Publicas http://www.mopc.gov.py/red-vial-s1
Bolivia	1,098,581	6,743	80,488	Estado Plurinacional de Bolivia ABC-Administradora Boliviana de Carreteras http://www.abc.gob.bo/mapas-de-la-red-vial-fundamental
Peru	1,285,216	5,536	139,295	Gobierno de Peru - Ministerio de Transportes I Comunicaciones http://renac.mtc.gob.pe/inventariovial/default2.aspxMapaVial
Chile	756,252	6,171	77,764	Gobiernode Chile Min Obras Públicas Red Caminera http://www.mapas.mop.cl/cc2013/red-vial-2013-cuadernillo.pdf

Table 1[1] - South America national states information and road maps and databases

1 Complementary information sources in Table 1:
http://www.ibge.gov.br/home/geociencias/cartografia/default_territ_area.shtm;
http://pesquisarodoviascms.cnt.org.br//PDFs/Resumo_Principais_Dados_Pesquisa_CNT_2016.pdf

Figure 2 - South America Geopolitical Map (left) and its continuous road network (Fauri; Braga, 2015).

Combining different simplification and generalisation methods allowed us to depict the network model topo-geometric structure at a) continental scale; b) national scale; c) regional scale: subsets / transnational development projects framings into 6 subsets (Chart2).

SUBSET	NATIONAL STATES	BOUNDARIES LIMITS	JUSTIFICATION	GROUPING CRITERIA	PLANNING UNIT
Subset 1	Argentina, Brazil, Bolivia, Chile, Paraguay, Peru, Uruguay	Brazilian (N) Amazonia borderline	Road connections inexistent / precarious	Contiguity; cross-border continuity	National States territories
Subset 2	Argentina, Brazil, Chile, Paraguay, Uruguay	National territories	Shared borderlines	Contiguity	Brazilian Frontier Strip South Arc
Subset 3	Brazil, Bolivia, Paraguay, Peru	National territories	Shared borderlines	Contiguity	Brazilian Frontier Strip Central Arch
Subset 4	Brazil, Argentina, Chile, Paraguay, Uruguay	From Belo Horizonte (BR) to Santiago (CH)	Territorial planning: development axes	Interaction potential	MERCOSUR-Chile Axis (IIRSA, 2012)
Subset 5	Argentina, Brazil, Paraguay, Bolívia, Peru	From Rio de Janeiro (BR) to Lima (PE)	Territorial planning: development axes	Interaction potential	Trans-Oceanic Axis (IIRSA, 2012)

Table 2 - South America road networks models subsets

The multiscale urban network analyses were based on cities relative position within South American road network. Space Syntax modeling methods (Al-Sayed *et al*., 2013) were tested on a pilot study (Braga *et al*, 2016) enlarged on this ongoing research. To verify the hypothesis, axial and segment modeling were performed with Depthmap x 0.5 (Varoudis, 2013; Hanna *et al*., 2013). Axial and angular analysis performed for each subset at global and local topological radius intend to verify the effciency in establishing territorial decoupages to improve network connectivity. The following axial and angular measures were modeled:

a) Global Integration (HHRn, Int): *closeness centrality* nodes's adjacency or relative accessibility to infer origin - destination movement potentials within subset networks at global (n) and local radius (R50 and R80) in order to evaluate the degree of integration / segregation of urban networks in each national territory and spatial decoupages;

b) Choice: *betweenness centrality* (bridge effect on flows probability) computes a node's frequency in every possible path used to reach other nodes in the network, displaying the shortest paths from all origins to all destinations and forecasting traffic flows ((Hillier et al., 2007 & Hanna *et al*., 2013); was apllied to evaluate borderline gateways hierarchical position towards cross-border and transnational flows probability.

3. DISCUSSION AND RESULTS

The discussion is based on the modeling of subsets displayed in Chart 2, which measurements provide the basis for qualitative comparisons as follows. The analysis of Subset 2,comprising the continental and each national road network (Figures 3 ,4) unveils differences on Portuguese and Spanish colonization processes and the integration structure underlying modern national states territorial configuration. Global integration axial measure (HH-Rn) informs that road networks are sparse, tending to spread from main seaports dating back to colonial times, linking capital cities to the territory - Uruguay, Chile and Peru -. Their syntactic centres configurations validate the polarization processes where functions and population are concentrated in a single metropolitan area, contrasting with the inland sparse urban network.

Locked out countries (Wilmsmeyer; Sanchez, 2009) - Paraguay and Bolivia - which national territories were defined from disputes over the La Plata Basin in late 19th century, display their road networks spreading from their geographic cores . Endogenous territorial integration is modified by the polarization exerted by terrestrial borderland with Brazil (E) that directs the syntactic centre to gateways such as the triplet-cities *Ciudad del Este* (PA)- *Foz do Iguaçú* (BR) and *Iguassú* (AR) and the connection Campo Grande (BR)- Santa Cruz de la Sierra (BO).

Brazil road and urban networks are denser and more evenly distributed connecting a larger number of small and medium size towns, therefore displaying different polarizations at global and local scales. Strategies to occupy the territory dating back to 1960ies included a new capital - Brasília (1960) - in its geographic centre - what improved the urban network density inland and stretched the road network syntactic centre from São Paulo, Belo Horizonte and Rio de Janeiro (SE), towards Northeast and West regions.

A common feature to every country depicted in this sample is the presence of large areas where the network is scarcely connected, contrasting with their density around capital cities, both at global and local scale. Brazil is the exception, where integration is more evenly distributed. At local scale (HHR50) axial integration depicts the earlier occupied and explored regions (North East, South East and South) cores. The most segregated areas are *Amazonia* (rain forest), *Pantanal* (wet planes) where road network connections are scarce.

Apart from Peru, where differences between global and local integration depicts the area between *Potosi* (next to Bolivia borderline) and Lima, the actual Pacific coast city, global and local syntactic centres are equivalent; and Argentina where the polarization exerted by Buenos Aires (population share and functional concentration) does not correspond its territory syntactic centre which spreads from Baia Blanca - Rosario - Cordoba -Salta axes. Chile and Argentina road networks connections are affected by the *Andes* ridge barrier and the Patagonia discontinuous territory what insulates road networks in its southern stretch.

Highest integration measures are generally low (Chart3), best results achieved for most compact and bigger (in number of lines) road networks such as Brazil and Argentina (Chart 3). Chile lowest integration measure is tributary to its linear territorial shape and topographic barriers, that impact the road system, composed mainly of dead end roads linking segregated towns. Highest and mean global integration measures tend to be discrepant, since road network configurations concentrate integration along few lines, usually short range ones, spreading from Capital cities. That informs, at national territories scale, that large parts of inland territories are segregated a phenomenon intertwined with that of metropolisation, which is common to most South American countries.

This phenomenon is characterized by concentration of functions and population in single intensely urbanized areas (Capital cities) which configurational centrality prevails over sparse and weak urban networks, which exceptions are Brazil and Argentina. In the first case, Brazil morphological centrality is pushed North, under the influence of Brasilia which act as the main crossroad to territorial connections. As for Argentina, the same phenomenon occurs regarding *Cordoba* and *Rosario* that distribute integration along the axis linking Baia Blanca Port to Argentina northern borderland.

When it comes to local (or regional integration) modeled at radius 50, which was the one radius that depicted scale changes for most of national road systems, it depicted subspaces that inform endogenous territorial subsets as in Brazil (North / Centre-West) more segregated and sparsely occupied areas, South, Southeast and Northeast regions which morphological cores tend to be detached from capital cities, driven inland by the force of a national road (BR116). Other integration measures at local radius were modeled, but by force of homogenizing data, are not displayed here. Coincidence between global and local integration measures can be verified through synergy correlation (Rn x R50) displayed in Chart 3.

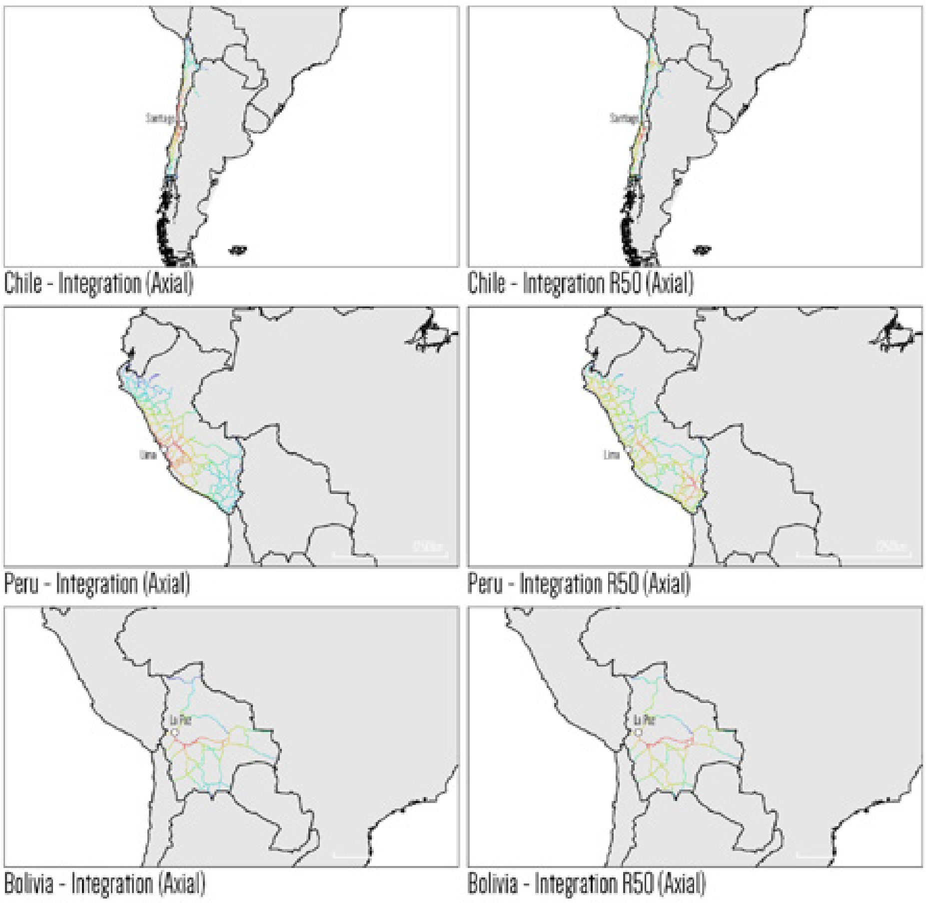


Figure 3 - Subset 2 - Axial global (HHRn) and local (HHR50) integration measures (FAURI, 2016).

National states ROAD SYSTEM	Number of axial lines	AXIAL INTEGRATION GLOBAL HHRn		AXIAL INTEGRATION LOCAL HHR50	SINERGY RnxR50 (R2)	AXIAL CHOICE (n)
		MAX	AVERAGE	MAX		
ARGENTINA	1557	0.1888	0.1385	0.2998	0.66	0.57485
BOLIVIA	600	0.1173	0.1010	0.2337	0.73	0.595765
BRAZIL	4964	0.1973	0.1278	0.3179	0.32	0.534227
CHILE	1180	0.0703	0.023	0.2619	0.3048	1.04071
PARAGUAY	525	0.2731	0.2198	0.2812	0.9769	0.331946
URUGUAY	612	0.3440	0.1747	0.3440	0.97	0.405266

Table 3 - Axial measures and synergy correlation for each national state road network

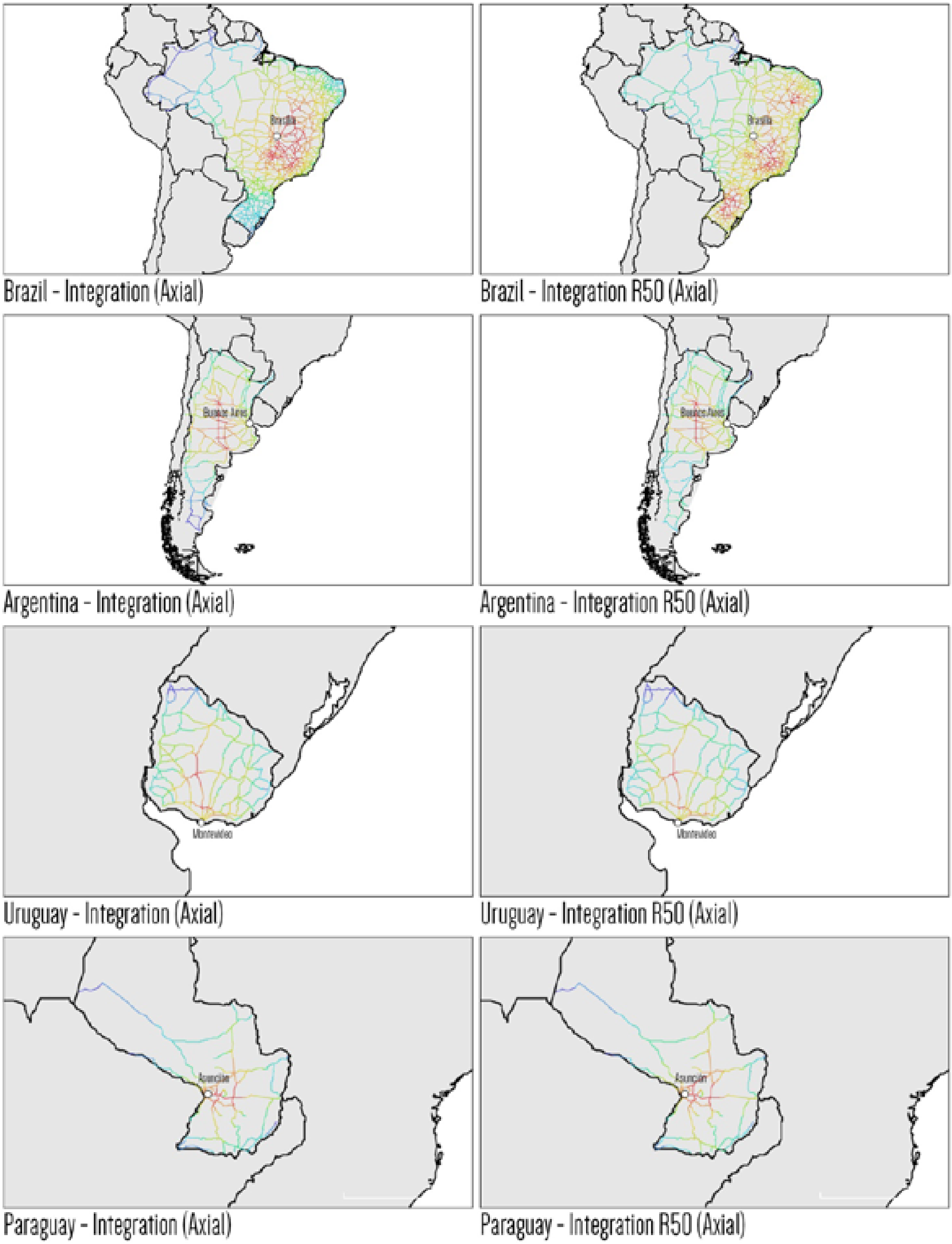


Figure 4 - Subset 2 - Axial global (HHRn) and local (HHR50) integration measures (FAURI, 2016).

From Figure 5 it is possible to attest that routes crossing the continent with highest flow probabilities spread from Brazil SE region, where São Paulo, Rio de Janeiro and Belo Horizonte metropolitan regions tend to form a dense and highly connected road network depicted by Angular Choice Global measure (network / subset 1).

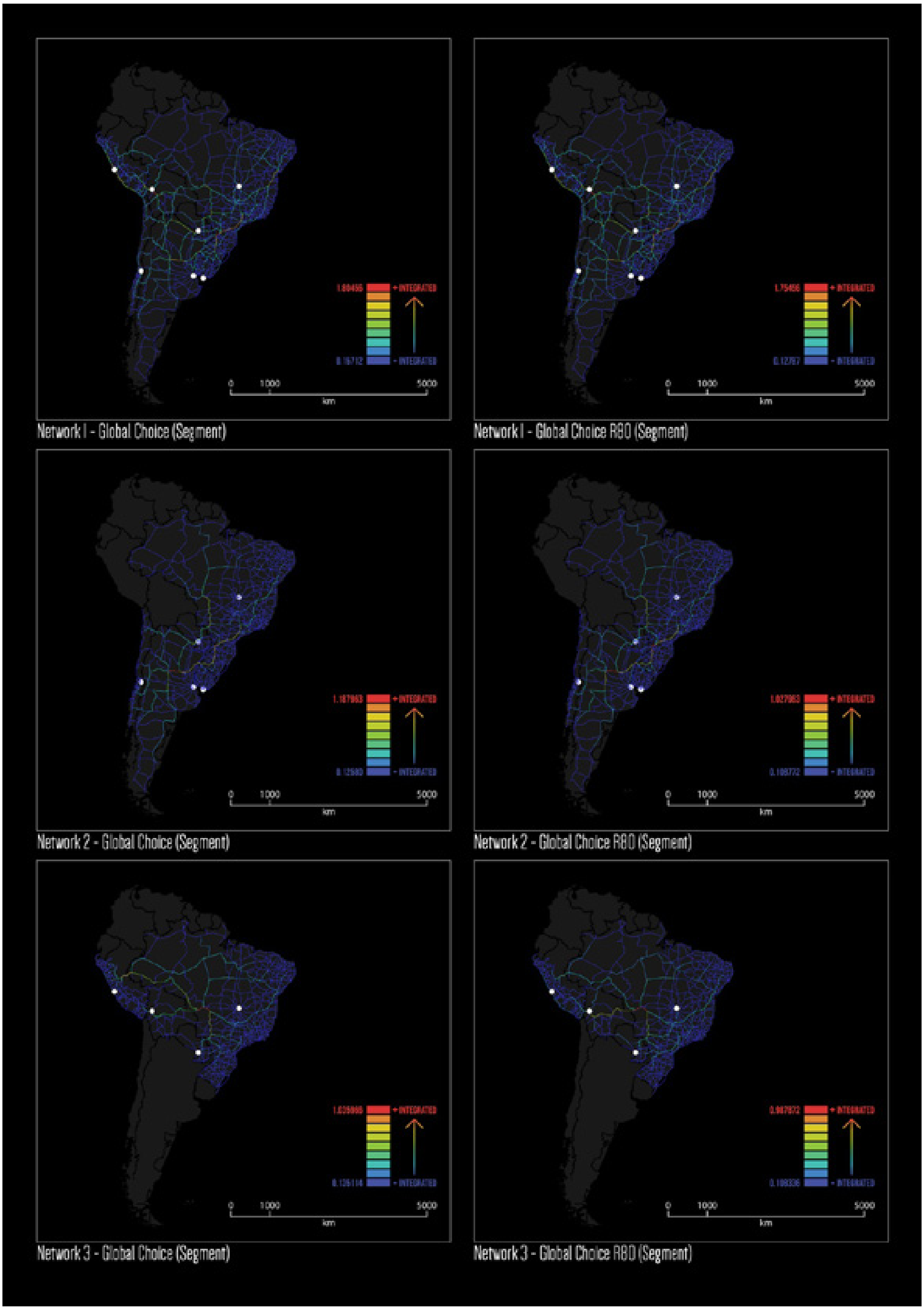


Figure 5 - Global / Local (R80) Angular Choice: Subsets 1 (above), 2 (centre) and 3 (below). Fauri, 2016.

This polarization tendency at continental scale is confirmed through Angular Choice for Subsets 2,3 (Figure5) at global scale, where the measure captures higher flow probabilities spreading from Brazil SE towards main cross-border gateways (SW - NW). The measure validates the functional polarization exerted by these three main production hubs distant 500km from each other, as the core of South America road system. These findings attest for the strength of *La Plata River Basin* in structuring the continental inland urban network and the relevance of road networks continuity across territorial limits. Transnational and cross-border flow probabilities inform twin-cities located along Brazil Southwestern borderline functional specialization, phenomena related to morphological and topo-geometrical properties of road networks.

Angular Choice at radius R80 depicts routes linking São Paulo to Pacific cargo seaports in Chile and Peru, that equals IIRSA development axes MERCOSUR-Chile and InterOceanic. Subset 2 *Uruguaiana* (BR) is depicted as the borderline gateway with highest flow probability, and *Mendoza* (AR), the main *Andes* crossing between Argentina and Chile. Subset 3, the route segment between Campo Grande (BR) and Cochabamba (BO), has the highest flow probability connecting Brazil (W) and Bolivia to Peruvian ports.

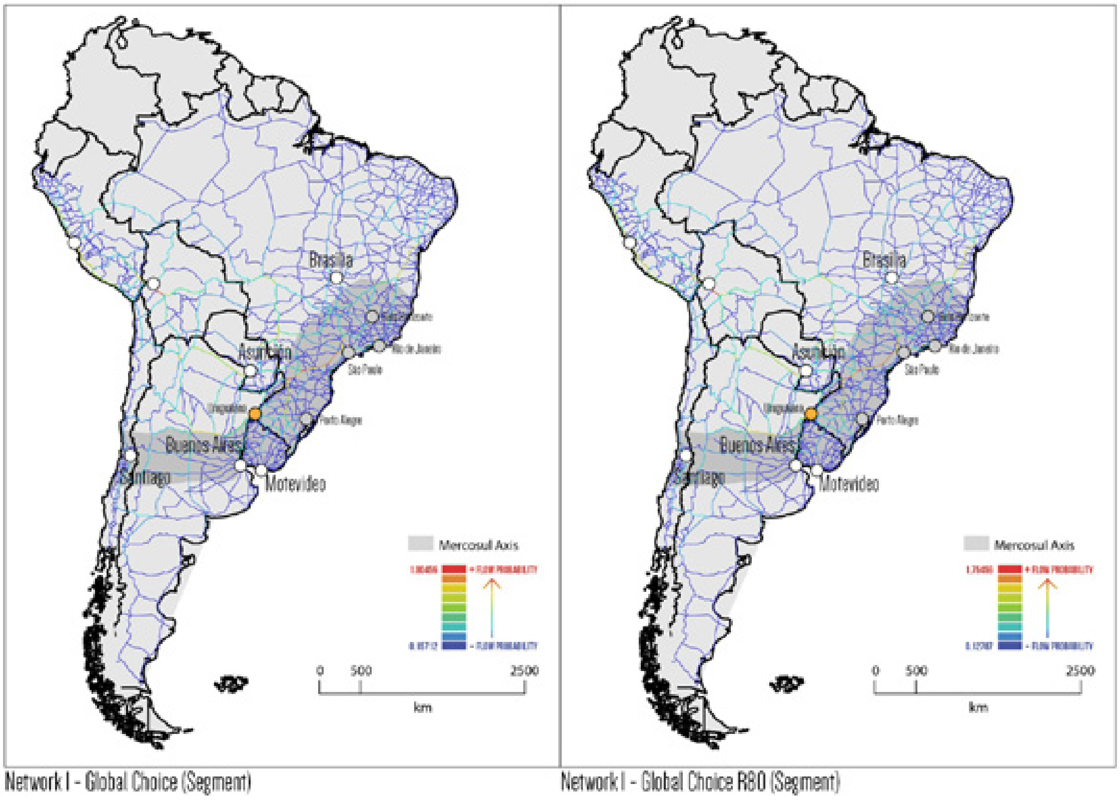


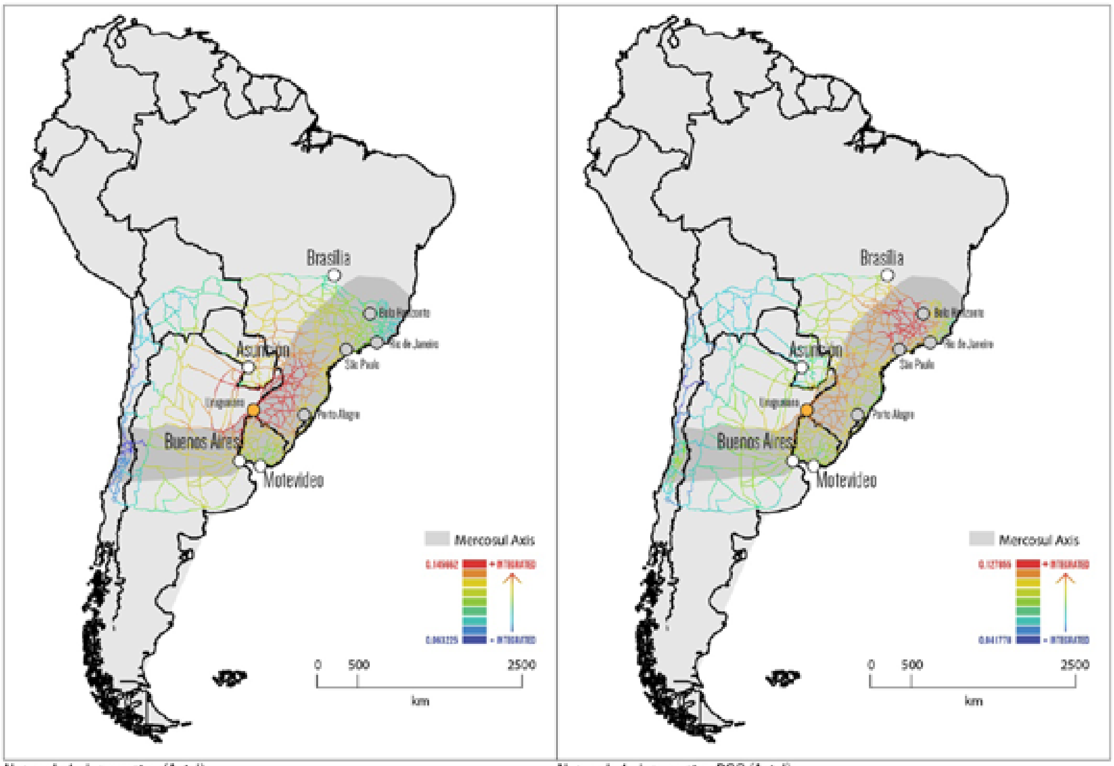
Figure 6 - Subset 4 MERCOSUR-Chile Development Axis: Angular Choice global, local (R80). Fauri.2016

For instance, through *Uruguaiana* (BR) (Figure 6), encompassed by 3 development axes (IIRSA, 2012), cross-border transit reaches 700 trucks per day. This town, distant more than 1000km from São Paulo, has the biggest South American logistic hub in commodities volume. At this gateway, cargo flows towards Argentina are 5 times higher than from there to Brazil. Hence the spatial logic underlying changes in functional specialization phenomena within urban networks nodes reinforces the importance of cross-border flows at the continental scale, targeted by transnational territorial planning strategies.

Transnational integration goals for urban network subsets economic development relay on flow probability across regional space as in MERCOSUR-Chile Development Axis (IIRSA, 2012). Despite efforts to minimize flow unevenness through cross-border gateways and, by doing so, improve t cargo transportation time, the topo-geometric network proprieties prevail in selecting the main gateways (cross-border bridge effect) along territorial borders, where logistic hubs are located. These effects are enhanced by infrastructure investments and cooperation projects, which firstly targeted to channel cargo cross-border flows through few surveillance gateways - as the International Bridge at *Uruguaiana - Paso de los Libres* (BR-AR binational project, 1945) and, nowadays, the focus is to provide infrastructure to segment cross-border cargo flows in order to diminish cargo transport time.

Busy cross-border gateways such as *Foz do Iguaçú* (BR) and *Uruguaiana* (BR) are highlighted at global scale choice measure, what confirms their roles as logistic and commercial hubs on the La Plata River influence area. They attest for regional integration resilience that differentiates exchanges and interactions, informing cultural hybridization and cross-border economic and functional complementarities within the urban network what, at local scale, give emergency to gateways functional specialization phenomena. Integration limits a region encompassing the whole Southeast Brazil, sprawling southwards.

Analyzing Axial Integration measure at global (HHRn) and local (HHR50) radius it becomes clear that at global scale, that the syntactic core of South America coincides with the La Plata Basin influence area, which has been disputed by Brazil and Argentina for long and that gave emergency to Uruguay and Paraguay national states. At local scale, the syntactic core of South America remains in Brazil, this time depicting the area between Brasilia and São Paulo tending to sprawl towards West, encompassing Paraguay, Bolivia and Northern Argentina territories a frontier region that depicts the influence Brazilian urban network exerts over its neighboring national state. (Figure 7). It is important to stress that network centrality measures such as angular choice, modeled at different scales and spatial limits, depict flow probability providing preliminary evidences informing cross-border gateways functional specialization phenomena. Multivariate analysis encompassing other dimensions of the phenomena, might validate or change such tendencies, specially local scale analysis (Campos; Braga; Lucca, 2017).



Network 4- Integration (Axial) Network 4- Integration R80 (Axial)

Figure 7 - Axial Integration at global (HHRn) and Local radius (HHR50), highlighting the MERCOSUR-Chile Development Axes (IIRSA, 2012) spatial limits. Fauri, Braga, 2016.

4. CONCLUSIONS: MAPPING THE STRUCUTURE OF CONTINENTAL CHANGES

This paper presents preliminary findings on South America road and urban networks interactions that indicate the morphological variables informing cross-border gateways functional specialization and polarization processes within urban network regional subsets. The main target in this stage of research was to overcome the methodological problems refereeing to the size of the continental road network; asymmetries and classification differences between national road networks and distortions in the geographical shape of national territories in planar projections.

Focusing on a qualitative approach to the problem, which limits were established by lack of homogeneous methodological parameters for statistical data to each national territory, as well as automation of simplification and generalisation routines to represent the network model, we draw few conclusions from the analysis performed. From these, we highlight the fact that researches insights that different network decoupage methods modified national road networks centrality hierarchies at different scales, hence related to configuration changes imposed by cross continental accessibility on regional subsets or spaces was validated.

Integration measure axial modeling provided sufficient evidence to discuss the problem, since the analysis focused mainly network topology at this research stage. Topological and topo-geometric analysis reiterated the integration cores and route choice systems across the continent. Specifically, different subsets confirm the dominance of Brazilian road network over the whole continent related to the network geometry, compacity and connectivity, capturing flow probability within its territorial limits; what enhances unevenness in the relations with neighboring countries and regional block partners.

Restrictions for road network connections to the North and Northwest are presented by Amazonian rain forest, that spreads from Brazilian Atlantic coast to Peruvian Pacific one as well as *Andes* ridge which barriers draw blanks on the road network circulation system. Most CSIPLAN - IIRSA projects (2015;2016) incorporate other transport modals and development axes investments target to improve connectivity between transport systems. Since July 2016 COSIPLAN-IIRSA (2016) publish an on-line / open access GIS platform from which we expect to obtain the cartographic data that enables syntactic analysis performed on an accurate road center line database. Nevertheless, scale problems persist and the development of decoupage and generalization methods are still the main problem we expect to face.

The hypothesis formulated here - that national road networks centralities hierarchies are modified at different scales and different spatial limits, hence related to configuration changes imposed by cross continental accessibility and connectivity on regional subsets or spaces, was validated by evidences obtained through axial analysis. The continental urban network core lays in the same *La Plata River Basin* area of influence, along Brazil SW Borderline Strip, proving the resilience of this frontier, understood as a development and expansion area. What changed in the past hundred years is that national states power games changed from sovereignty pretenses to leadership ones.

The continental road network configurational properties depict polarizing tendencies and inform national and regional urban networks centrality hierarchies in which South American important metropolis like Buenos Aires, Santiago do Chile, Montevideo and Lima remain segregated from its morphological centre. We recall Milton Santos (2006, p.188) to illustrate his statement on the reshaping of territories. For that, we display Subsets 4 and 5 MERCOSUR-Chile and Trans-Oceanic Development Axes modeling (Figure 8). From this, it is possible to note the expansion of cross border spaces spreading from Brazilian productive poles to Pacific seaports through which transnational cargo flows are reshaping territories and effectively changing the urban networks' spatial limits, what gives emergency to new territorial orderings. These are enhanced through cooperation projects and incorporated into transnational planning tools, which agency is not exempt of domination, exerted by MERCOSUR founding members over South America continent.

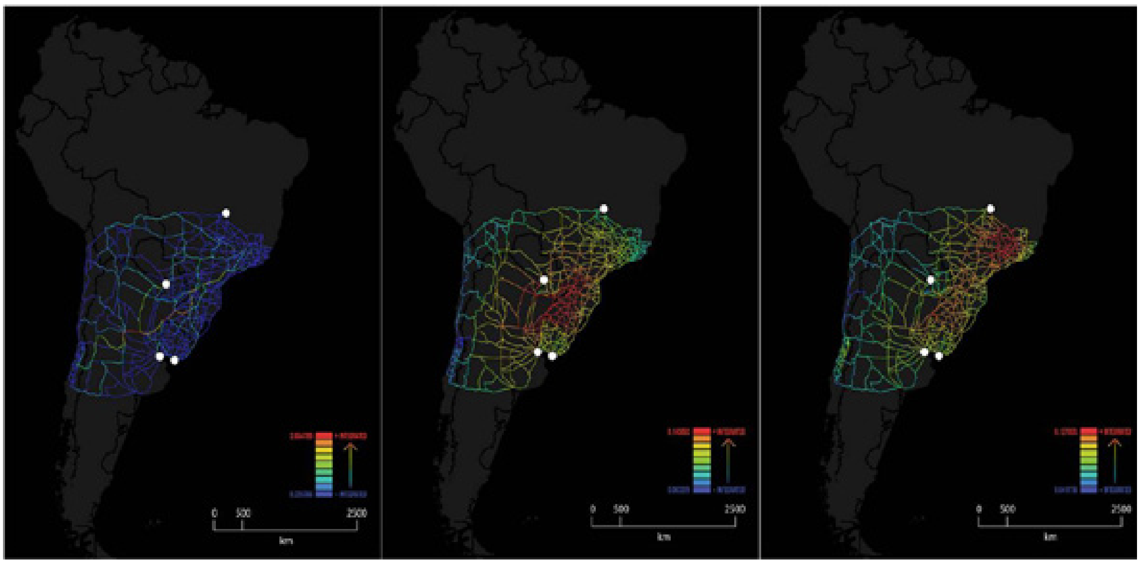


Figure 8 - Subsets 4 and 5 fused angular analysis: Global Choice (left); Integration (centre); Integration R80 (right). Fauri; Braga, 2016.

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