Update of the Velocity Field Model for South America

Hermann Drewes
Deutsches Geodätisches Forschungsinstitut
München, Germany

SIRGAS General Assembly, Montevideo, Uruguay, 2008

Status of the Velocity Model for South America

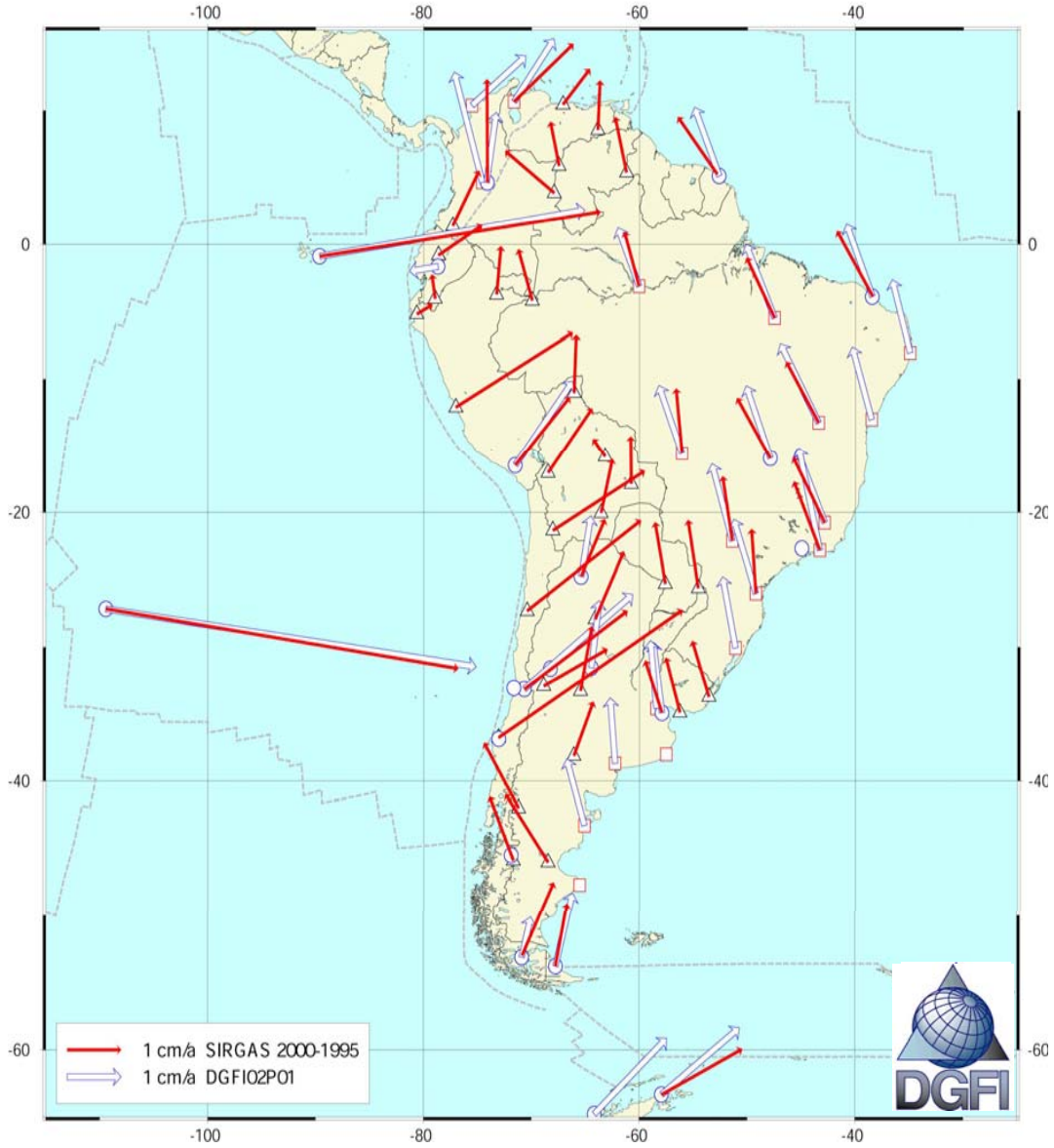
A velocity field model for the South American continent (VEMOS) was computed for the first time in 2003 (Drewes and Heidbach 2005). It was based on the following continental GPS station velocity solutions:

- DGFI02P01 of IGS RNAAC-SIR (Seemüller et al. 2002),
- SIRGAS 2000 – 1995 campaigns difference vectors,

and point velocities from five GPS geodynamics projects:

- CASA-East (Kaniuth, Drewes, Hernandez, Hoyer et al.),
- CASA-West (Kellogg, Freymueller, Mora et al.),
- SNAPP (Norabuena, Stein et al.),
- CAP (Bevis, Kendrick et al.),
- SAGA (Klotz, Khazaradze et al.).

Velocity Data for Model VEMOS 2003



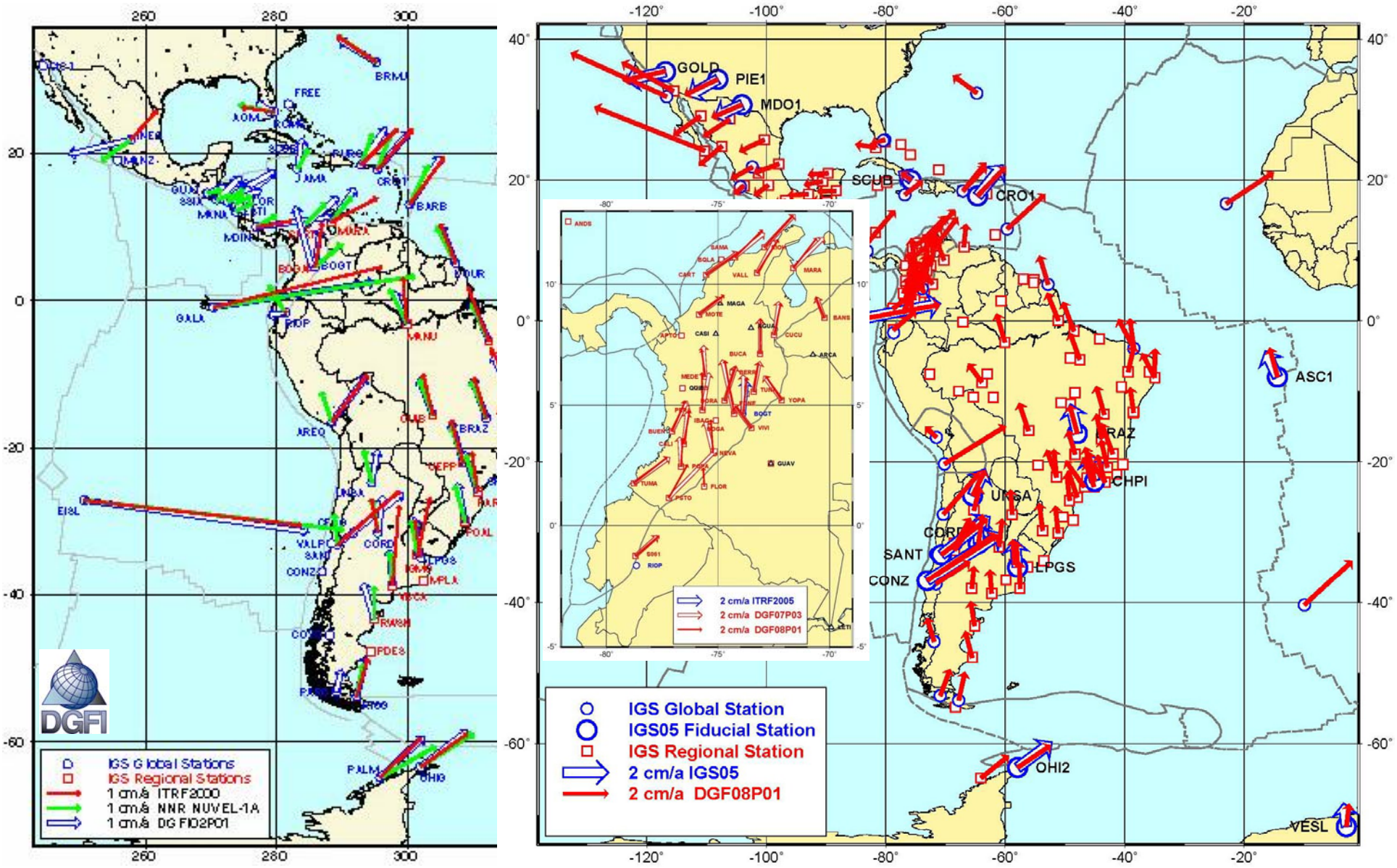
Motivation and Velocity Data for VEMOS 2008

In the meantime, new velocity data have been published and the accuracy of station velocities has increased.

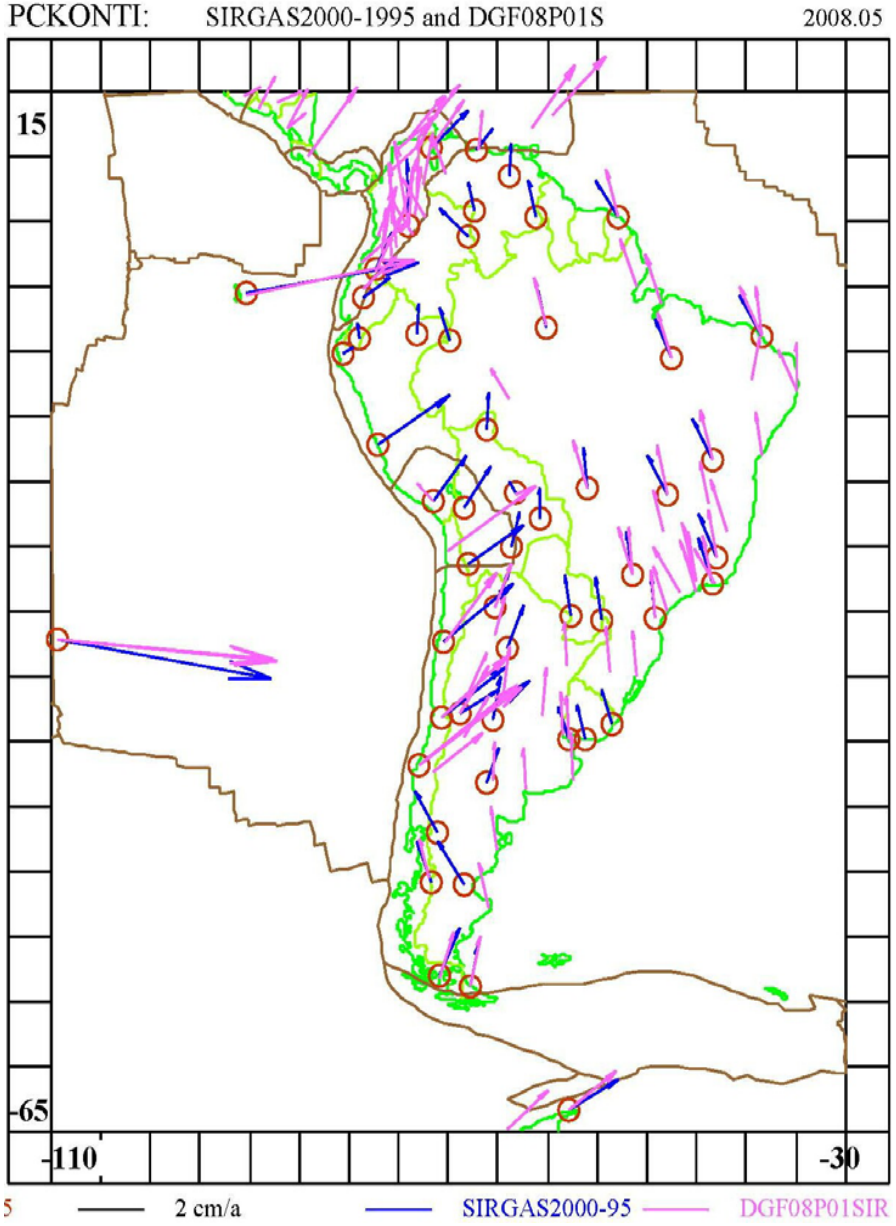
For the present computation we use data from projects

- DGFI08P01S (Seemüller et al. 2008)
- SIRGAS 2000 – 1995 differences (Drewes et al. 2005)
- CASA East (Kaniuth et al. 2002)
- CASA West (Trenkamp et al. 2002)
- CASA Cali, Colombia (Trenkamp et al. 2004)
- CAP (Kendrick et al. 2003)
- CAP-SNAPP integrated (Kendrick et al. 2001)
- SAGA (Klotz et al. 2001)
- SAGA (Khazaradze and Klotz 2003)

Motivation and Velocity Data for VEMOS 2008



Velocity Data for VEMOS 2008



Comparison of velocities DGF08P01 – SIRGAS 00-95

20 identical stations

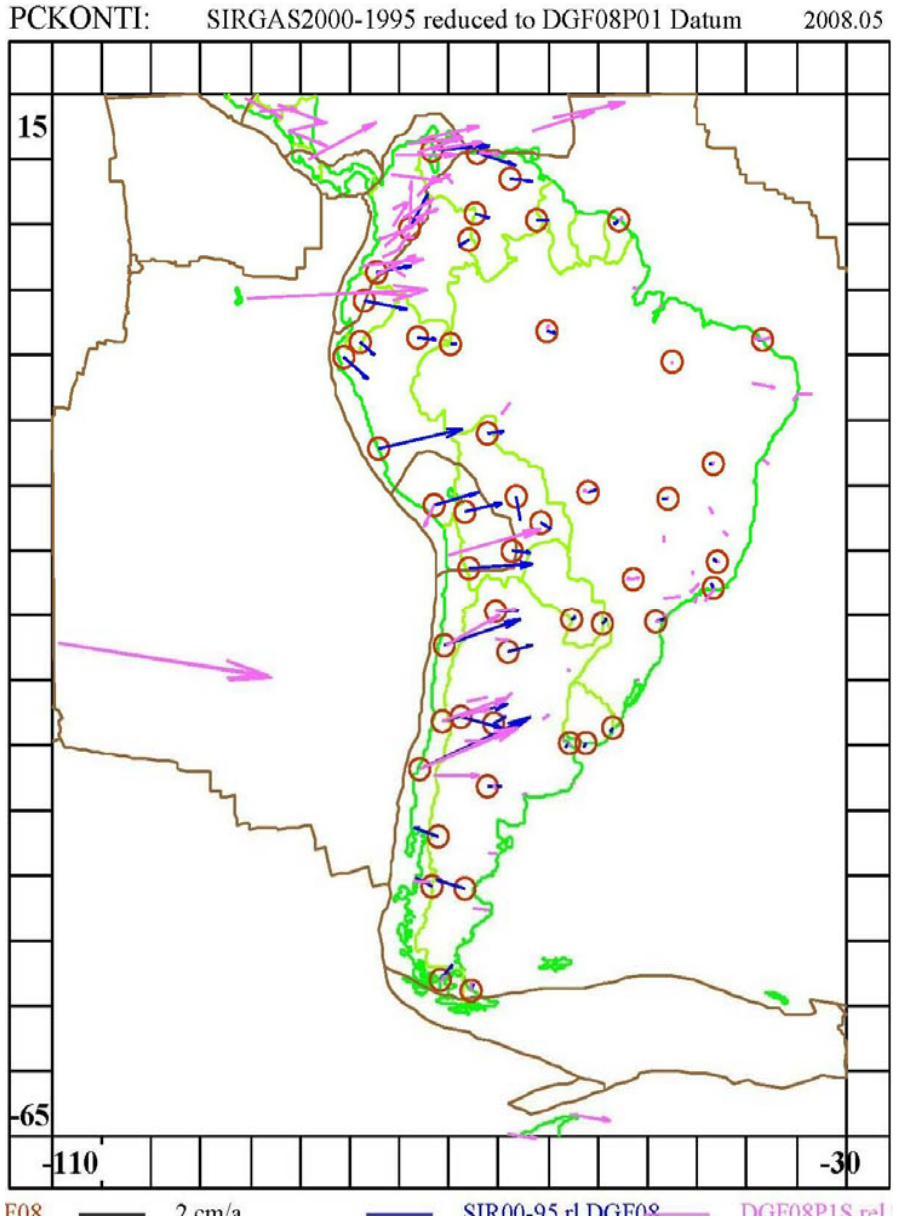
Bias : Δ_φ = -0.0019, Δ_λ = -0.0009 [m/a]

Max.: v_φ = 0.0021, v_λ = 0.0030 [m/a]

Min. : v_φ = -0.0048, v_λ = -0.0048 [m/a]

wrms: v_φ = 0.0021, v_λ = 0.0021 [m/a]

Velocity Data for VEMOS 2008



Comparison of velocities DGF08P01 – SIRGAS 00-95

20 identical stations

Bias : Δ_φ = -0.0019, Δ_λ = -0.0009 [m/a]

Max.: v_φ = 0.0021, v_λ = 0.0030 [m/a]

Min. : v_φ = -0.0048, v_λ = -0.0048 [m/a]

wrms: v_φ = 0.0021, v_λ = 0.0021 [m/a]

Relative to South American Plate internal rotation:

18 identical continental stations

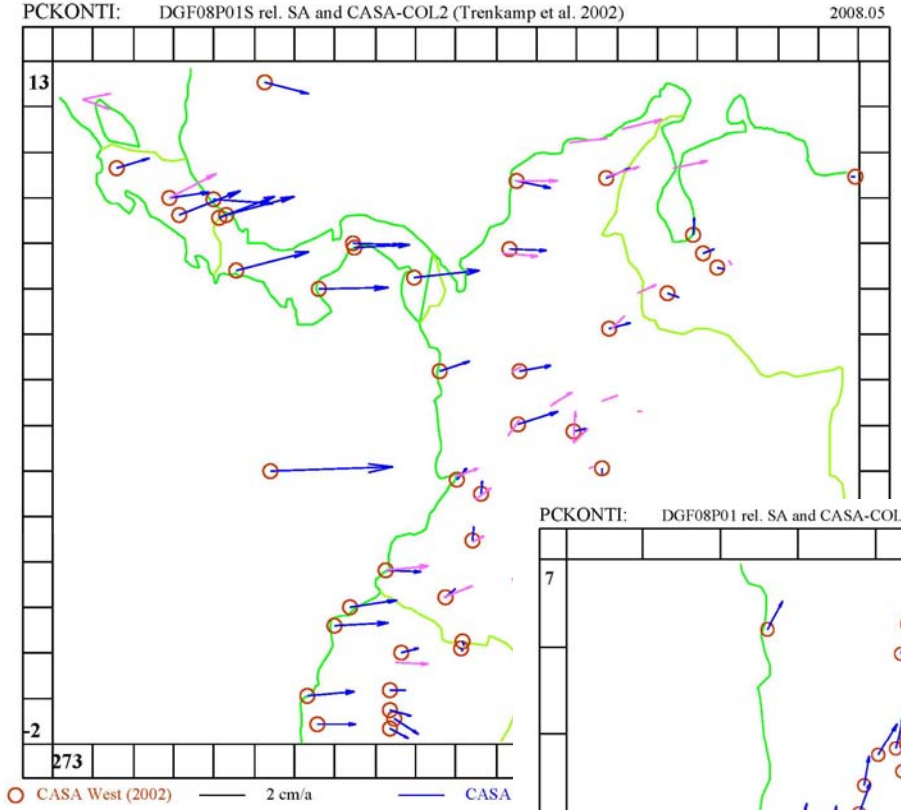
Bias : Δ_φ = -0.0001, Δ_λ = -0.0007 [m/a]

Max.: v_φ = 0.0035, v_λ = 0.0034 [m/a]

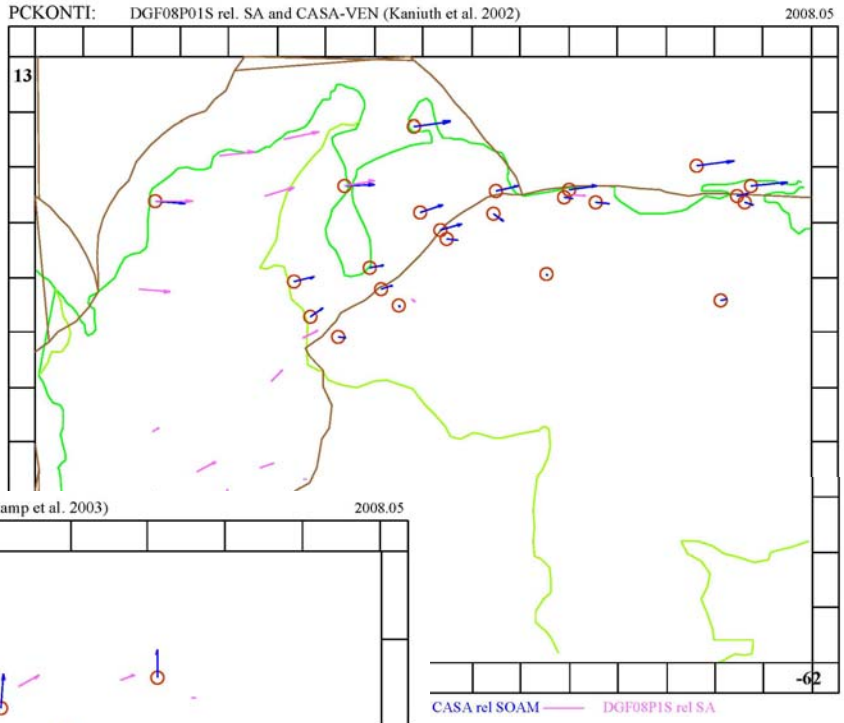
Min. : v_φ = -0.0015, v_λ = -0.0045 [m/a]

wrms: v_φ = 0.0011, v_λ = 0.0021 [m/a]

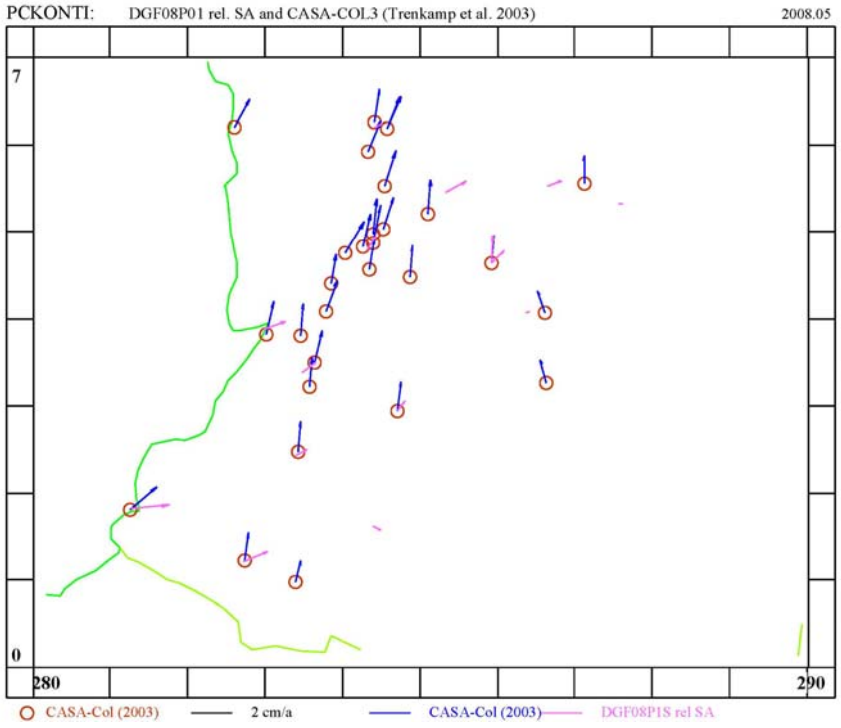
Velocity Data for VEMOS 2008



CASA (West)

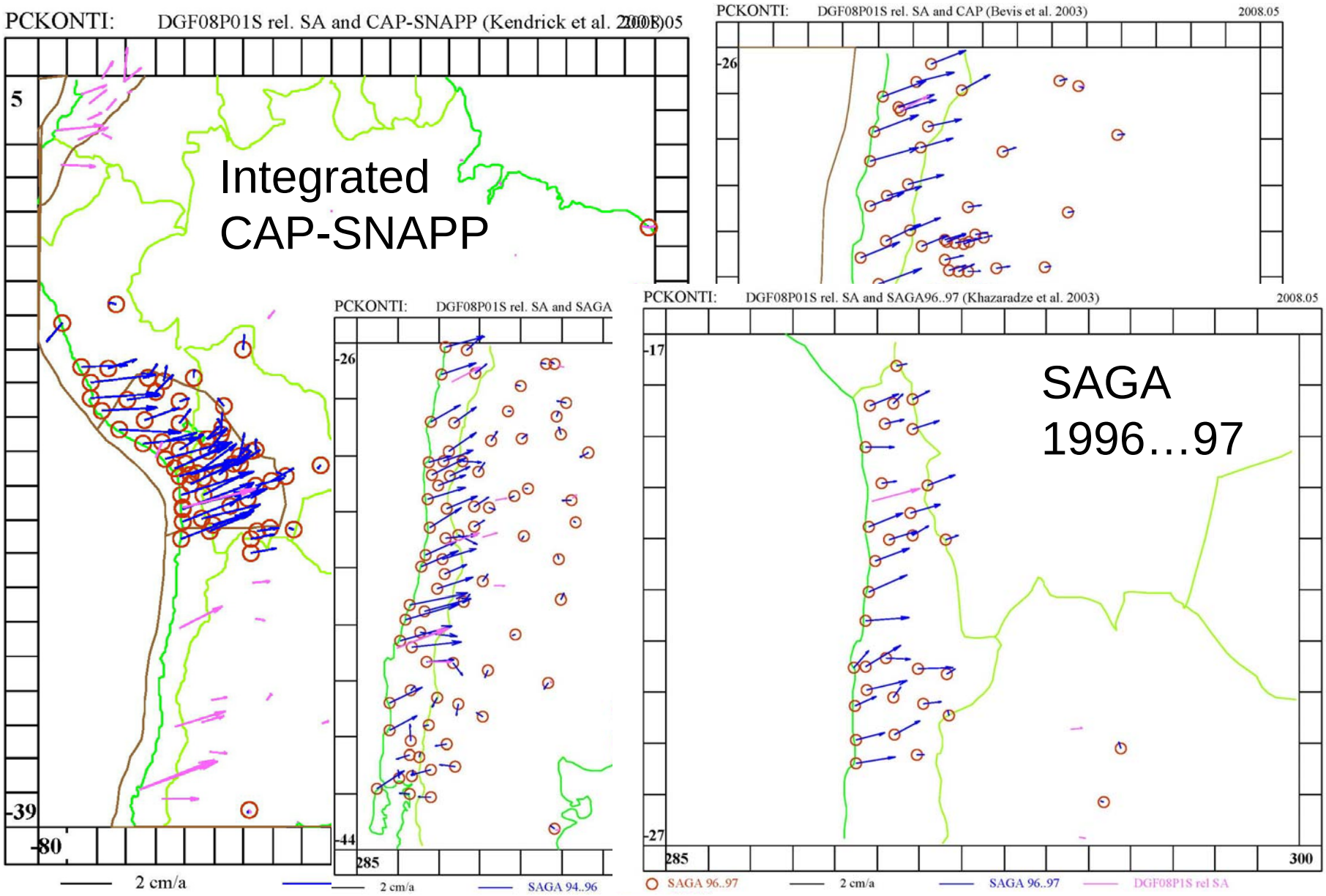


CASA (East)



CASA (Cali)

Velocity Data for VEMOS 2008



Comparison Project Data vs. DGF08P01S

CASA-West (9 ident. stations)

Bias: Δ_φ = -0.0015, Δ_λ = -0.0027 [m/a]
|max|: v_φ = 0.0071, v_λ = 0.0073 [m/a]
wrms: v_φ = 0.0029, v_λ = 0.0041 [m/a]

CASA-East (6 ident. stations)

Bias: Δ_φ = -0.0008, Δ_λ = -0.0021 [m/a]
|max|: v_φ = 0.0035, v_λ = 0.0077 [m/a]
wrms: v_φ = 0.0023, v_λ = 0.0036 [m/a]

CASA-Cali (9 ident. stations)

Bias: Δ_φ = 0.0083, Δ_λ = -0.0035 [m/a]
|max|: v_φ = 0.0127, v_λ = 0.0105 [m/a]
wrms: v_φ = 0.0084, v_λ = 0.0052 [m/a]

CAP (4 ident. stations)

Bias: Δ_φ = -0.0011, Δ_λ = 0.0008 [m/a]
|max|: v_φ = 0.0019, v_λ = 0.0044 [m/a]
wrms: v_φ = 0.0012, v_λ = 0.0024 [m/a]

SAGA (4 ident. stations)

Bias: Δ_φ = -0.0003, Δ_λ = -0.0036 [m/a]
|max|: v_φ = 0.0023, v_λ = 0.0080 [m/a]
wrms: v_φ = 0.0019, v_λ = 0.0054 [m/a]

CAP-SNAPP (8 ident. stations)

Bias: Δ_φ = 0.0008, Δ_λ = -0.0014 [m/a]
|max|: v_φ = 0.0012, v_λ = 0.0031 [m/a]
wrms: v_φ = 0.0008, v_λ = 0.0020 [m/a]

SAGA-N (0 id. Stations, 3 CAP-N)

Bias: Δ_φ = -0.0039, Δ_λ = -0.0044 [m/a]
|max|: v_φ = 0.0064, v_λ = 0.0053 [m/a]
wrms: v_φ = 0.0040, v_λ = 0.0044 [m/a]

Datum Reduction

The datum of velocities of the individual projects is reduced to DGFI08P01 by estimating the rotation vectors of identical stations (identical = distance < 10 km or 20 km, respectively)

CASA-Cali (9 ident. stations)

Bias: Δ_φ = 0.0083, Δ_λ = -0.0035 [m/a]
|max|: v_φ = 0.0127, v_λ = 0.0105 [m/a]
wrms: v_φ = 0.0084, v_λ = 0.0052 [m/a]

CASA-Cali (after datum reduction)

Bias: Δ_φ = 0.0003, Δ_λ = -0.0021 [m/a]
|max|: v_φ = 0.0044, v_λ = 0.0074 [m/a]
wrms: v_φ = 0.0021, v_λ = 0.0038 [m/a]

CAP (4 ident. stations)

Bias: Δ_φ = -0.0011, Δ_λ = 0.0008 [m/a]
|max|: v_φ = 0.0019, v_λ = 0.0044 [m/a]
wrms: v_φ = 0.0012, v_λ = 0.0024 [m/a]

CAP (after datum reduction)

Bias: Δ_φ = 0.0000, Δ_λ = 0.0000 [m/a]
|max|: v_φ = 0.0010, v_λ = 0.0033 [m/a]
wrms: v_φ = 0.0007, v_λ = 0.0021 [m/a]

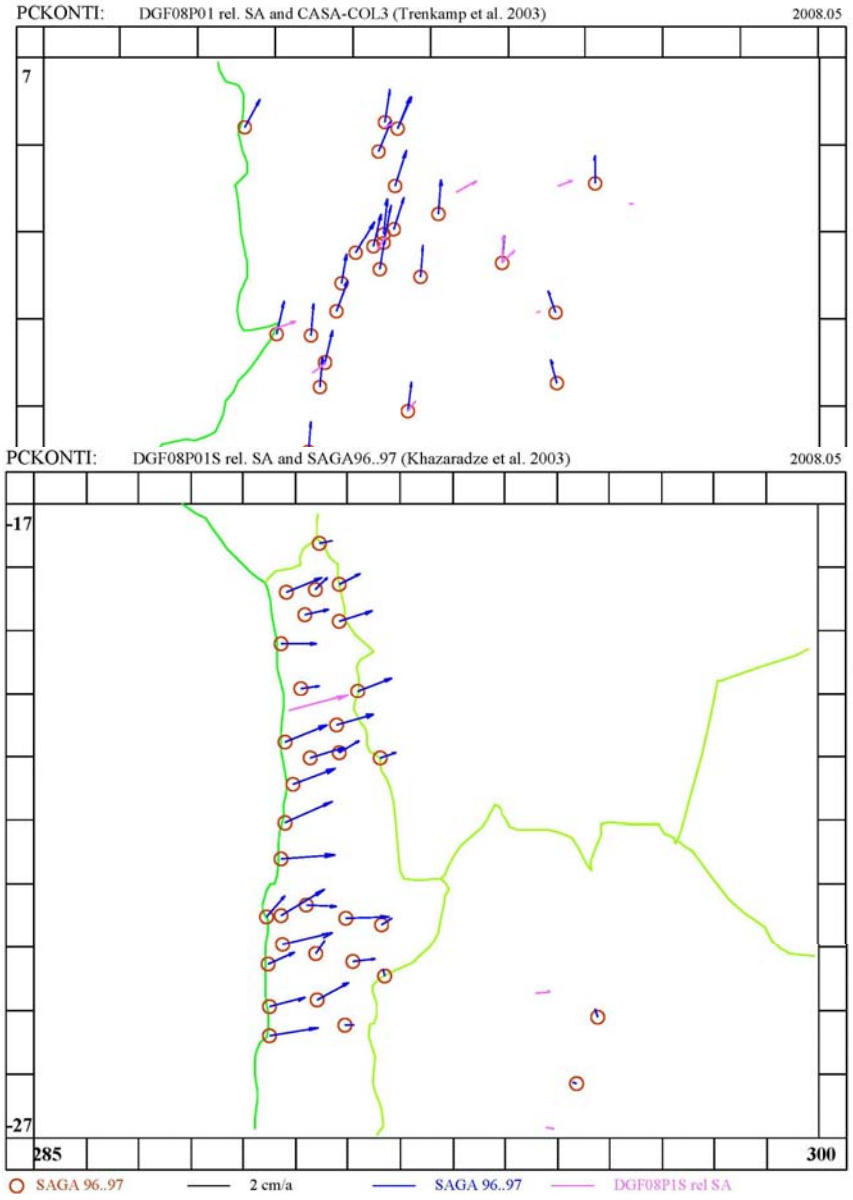
SAGA (4 ident. stations)

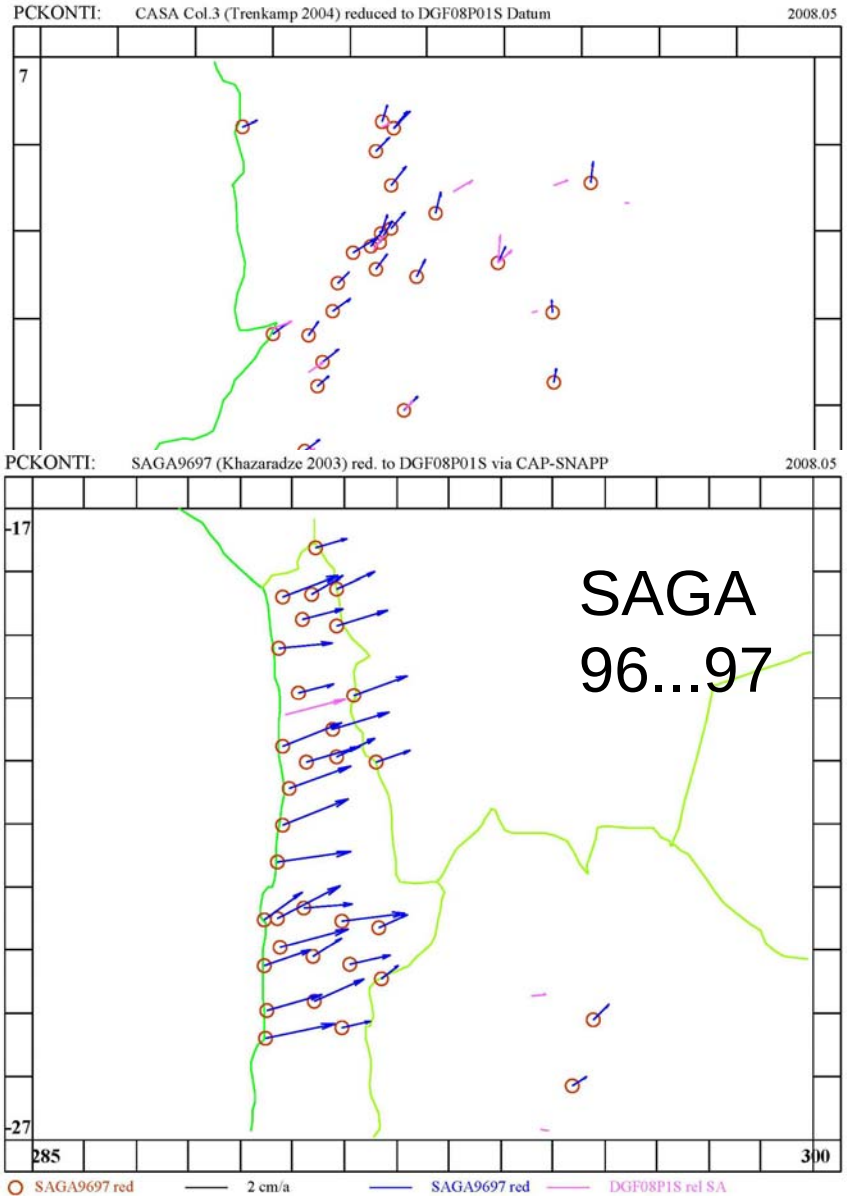
Bias: Δ_φ = -0.0003, Δ_λ = -0.0036 [m/a]
|max|: v_φ = 0.0023, v_λ = 0.0080 [m/a]
wrms: v_φ = 0.0019, v_λ = 0.0054 [m/a]

SAGA (after datum reduction)

Bias: Δ_φ = -0.0002, Δ_λ = 0.0002 [m/a]
|max|: v_φ = 0.0029, v_λ = 0.0047 [m/a]
wrms: v_φ = 0.0024, v_λ = 0.0028 [m/a]

Effects of Datum Reductions



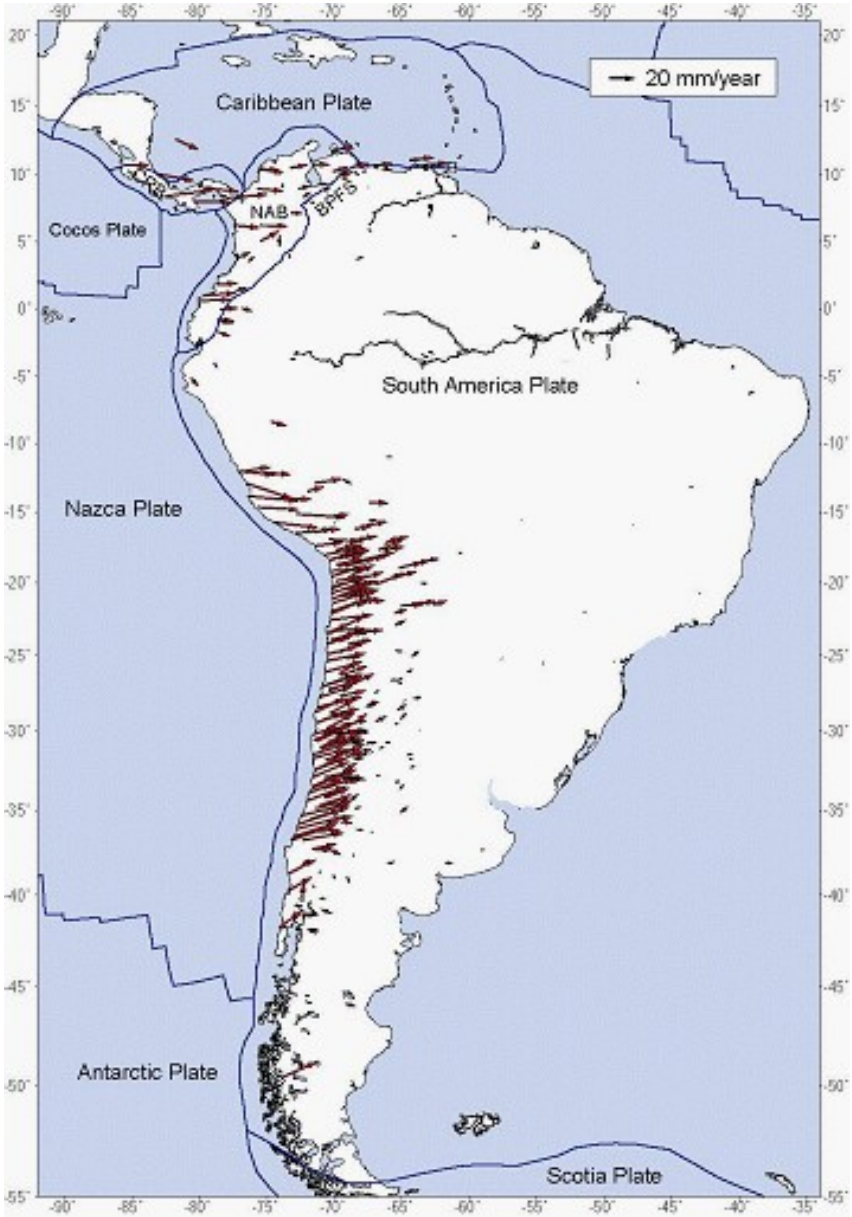


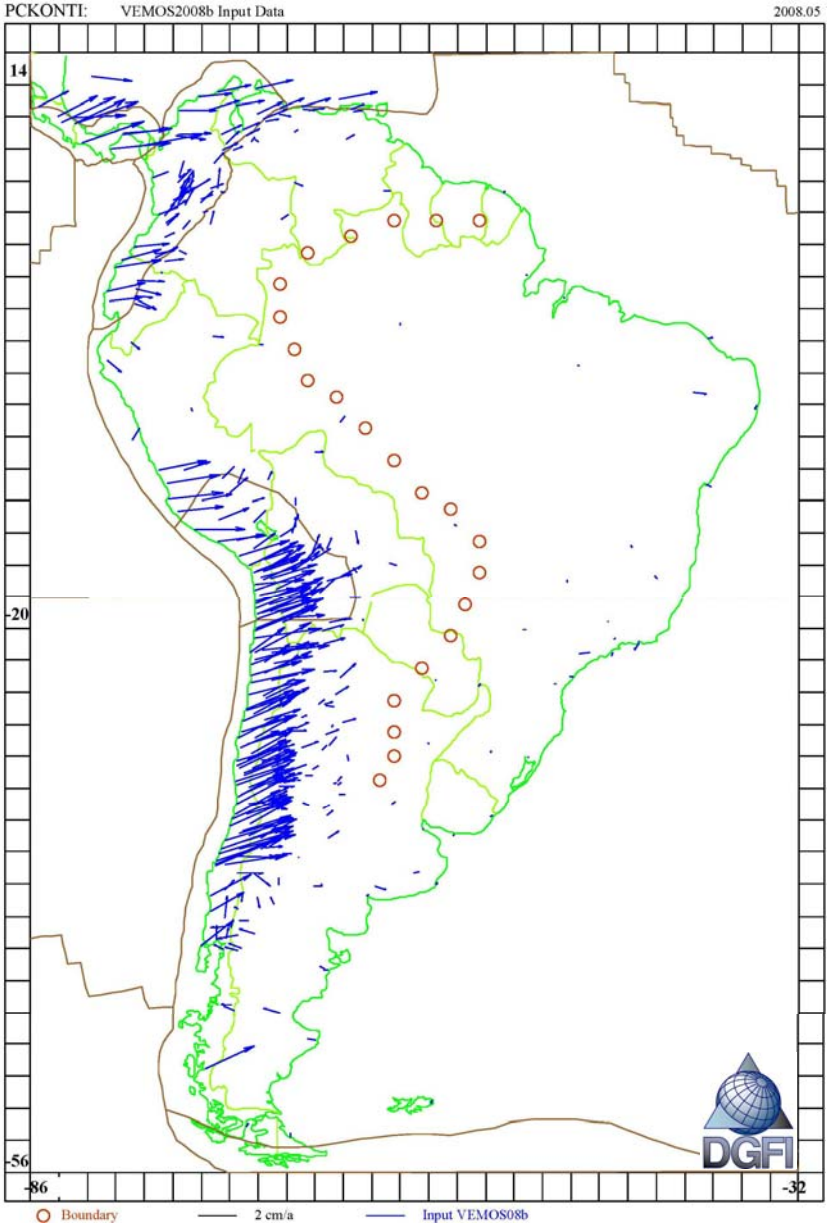
Final Input Data Set

Total numbers of station velocities in the modelled area and remaining after exclusion of double station occupations:

	Total	Used	
DGFI08P01S	83	77	
SIRGAS00-95	52	28	
CASA East (Venezuela)	27	19	
CASA West	43	22	
CASA-Cali	29	18	
CAP	68	58	
CAP-SNAPP integrated	69	54	
SAGA 96..97 (North)	33	32	
SAGA 94..96	79	69	
Sum		377	(2003: 329)

Input Data Comparison VEMOS 2003 - 2008



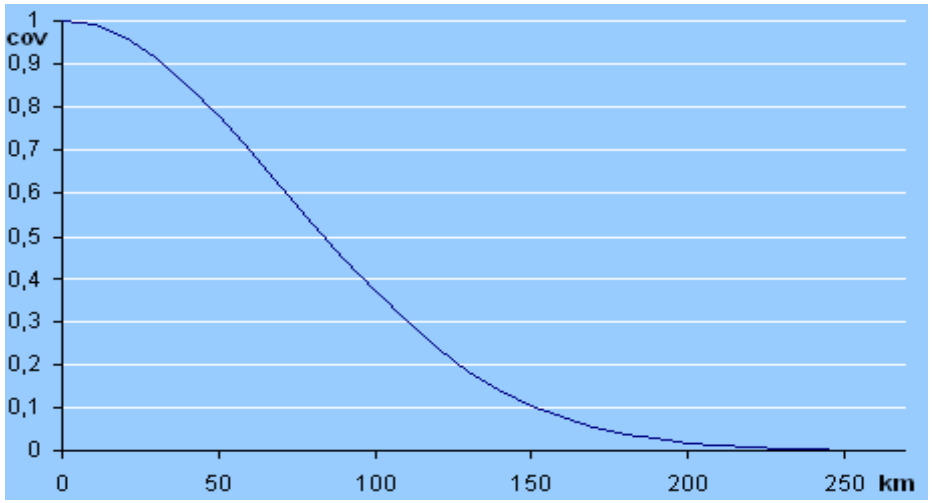


Procedure of Velocity Field Computation

Principle of least squares collocation (vector prediction):

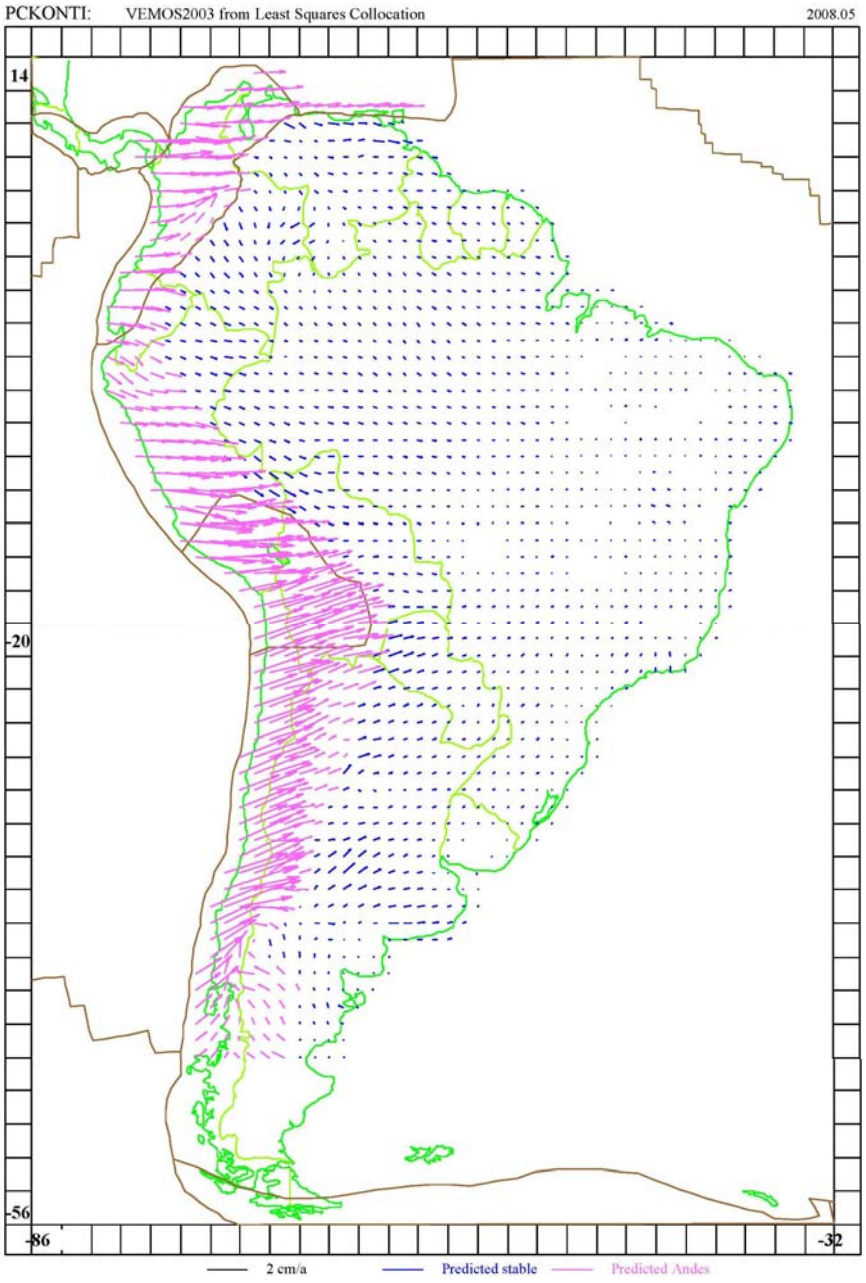
$$\underline{\mathbf{v}}_{pred} = \underline{\mathbf{C}}^{T}_{new}\,\underline{\mathbf{C}}^{-1}_{obs}\,\underline{\mathbf{v}}_{obs} \qquad \underline{C}_{ii} = \begin{vmatrix} \underline{C}_{\varphi\varphi} & \underline{C}_{\varphi\lambda} \\ \underline{C}_{\lambda\varphi} & \underline{C}_{\lambda\lambda} \end{vmatrix} \qquad \underline{c}_{ik} = \begin{vmatrix} \underline{c}_{\varphi\varphi} & \underline{c}_{\varphi\lambda} \\ \underline{c}_{\lambda\varphi} & \underline{c}_{\lambda\lambda} \end{vmatrix}$$

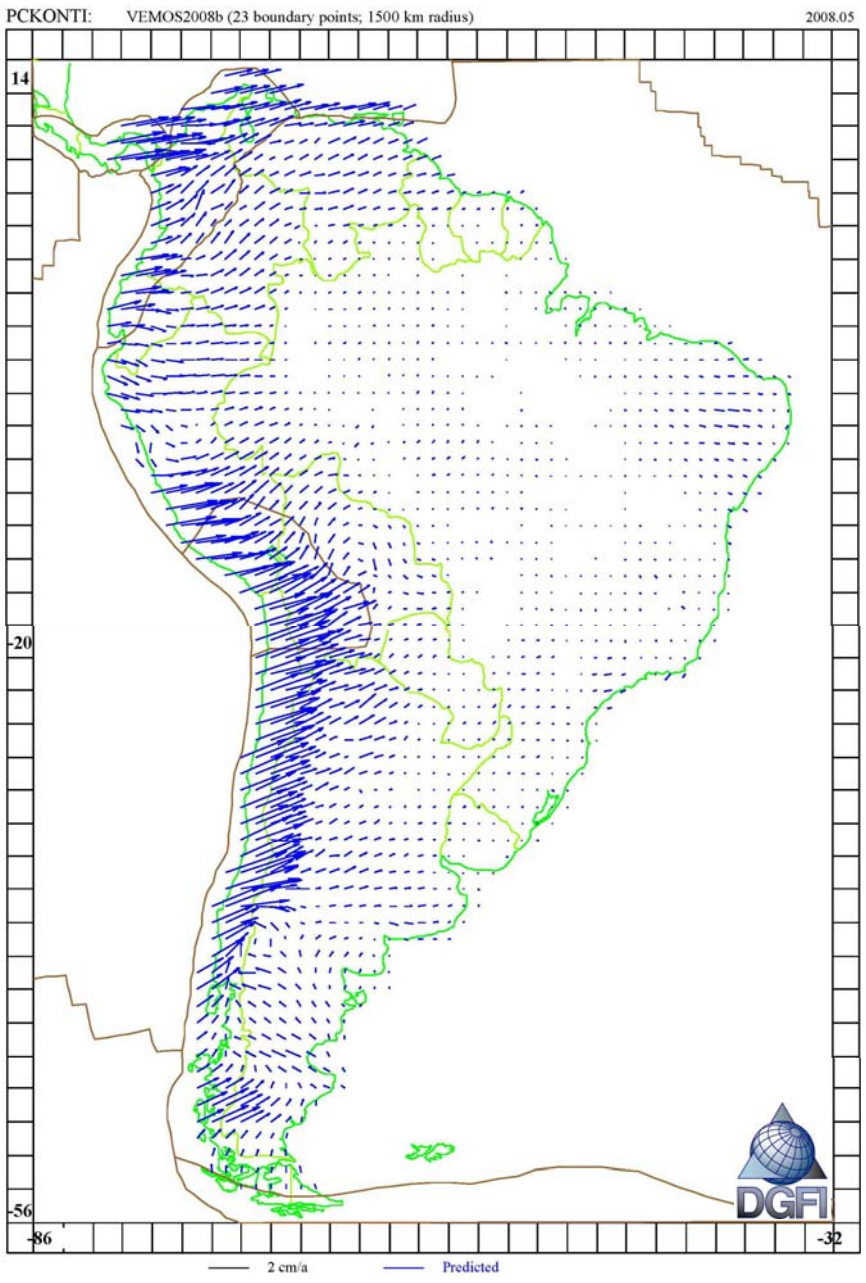
$\underline{\mathbf{v}}_{pred}$ = predicted velocities in arbitrary points (e.g., grid)
$\underline{\mathbf{v}}_{obs}$ = observed velocity in geodetic stations (observatories)
$\underline{\mathbf{C}}_{new}$ = correlation matrix between predicted and observed
$\underline{\mathbf{C}}_{obs}$ = correlation matrix between observed vectors



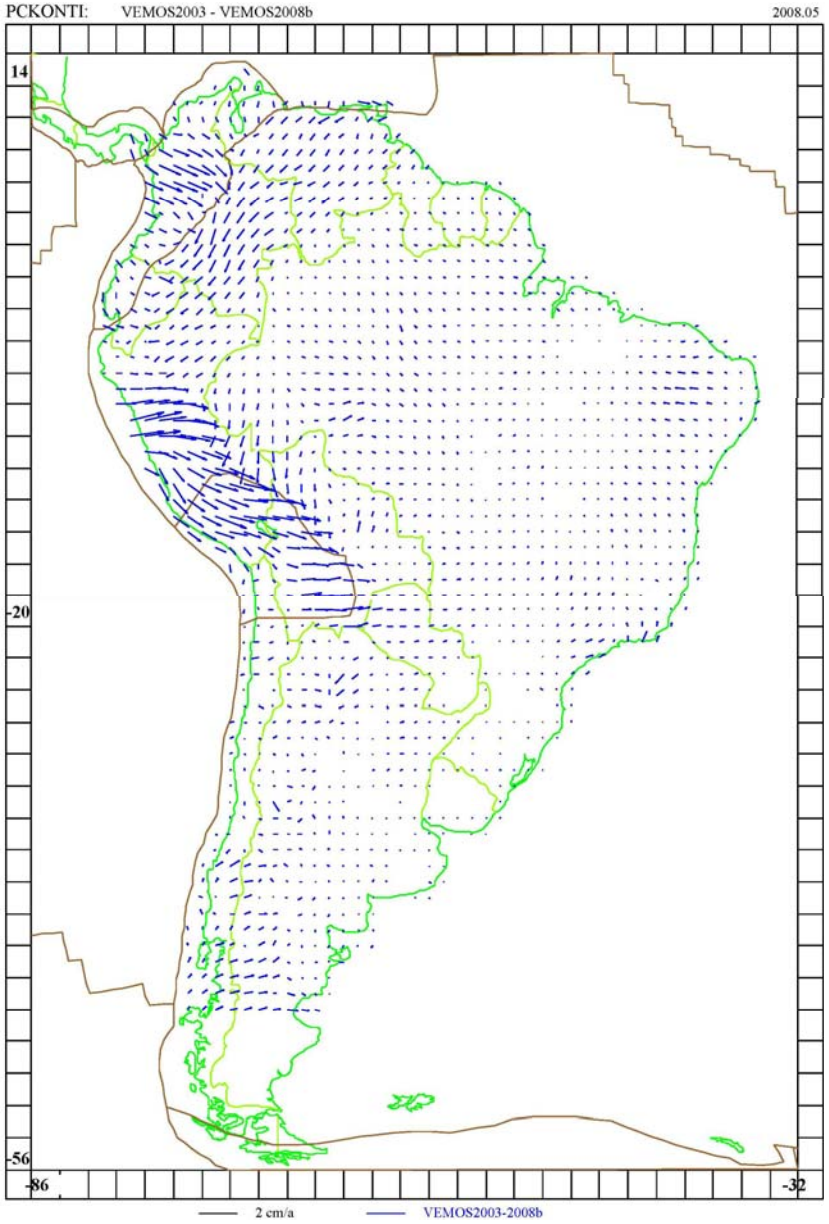
$\underline{\mathbf{C}}$-matrices taken from empirically estimated covariance functions computed from observed point velocities up to a radius of 3000 km.

Velocity Fields VEMOS 2003 and 2008





Comparison of Predicted Velocities



VEMOS 2003 - VEMOS 2008 (pred.)

Northern part (826 id. stations):
Bias: Δ_φ = -0.0011, Δ_λ = 0.0006 [m/a]
|max|: v_φ = 0.0076, v_λ = 0.0195 [m/a]
wrms: v_φ = 0.0013, v_λ = 0.0019 [m/a]

Southern part (814 id. stations):
Bias: Δ_φ = 0.0000, Δ_λ = 0.0012 [m/a]
|max|: v_φ = 0.0091, v_λ = 0.0160 [m/a]
wrms: v_φ = 0.0011, v_λ = 0.0016 [m/a]

Predicted station velocities DGF08P01
(91 stations, AREQ, BOGA elim.)

Bias: $\Delta\varphi$ = -0.0003, $\Delta\lambda$ = -0.0003 [m/a]
|max|: $v\varphi$ = 0.0035, $v\lambda$ = 0.0058 [m/a]
wrms: $v\varphi$ = 0.0012, $v\lambda$ = 0.0020 [m/a]

Conclusions

- The updated velocity field has an estimated accuracy of about ± 1 mm/a in North and ± 2 mm/a in East direction (quite similar as the 2003 velocity field).
- To improve the velocity field, more continuously observing stations are required to fill the gaps and to improve the quality of station velocities.
- National networks may be integrated in the velocity field computation (e.g. Argentina, Chile).
- Other data of geodynamics projects may be integrated into the modelling (e.g., CAP).