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EUREF 2018 SYMPOSIUM
AMSTERDAM 30 May – 1 June 2018

wissen wohin
savoir où
sapere dove
knowing where

swisstopo

Status Report on the Working Group on "European Dense Velocities"

Simon Lutz, Elmar Brockmann and
members of the EUREF Working Group

Outline

- Introduction
- Contributing solutions
- First results from the combination
- Summary

Introduction

A short history

- **EUREF Symposium 2016**, San Sebastian:
  Brockmann E: «Densifying Velocity Fields in Europe: Advantages of the Classical Approach»
- **March and April 2017**:
  Draft charter «EUREF Working Group on 'European Dense Velocities'»
- **EUREF Symposium 2017**, Wrocław:
  - Brockmann E: "Towards a European Dense Velocities Field"
  - EUREF 2017 Resolution No. 2:

The IAG Reference Frame Sub-commission for Europe (EUREF)

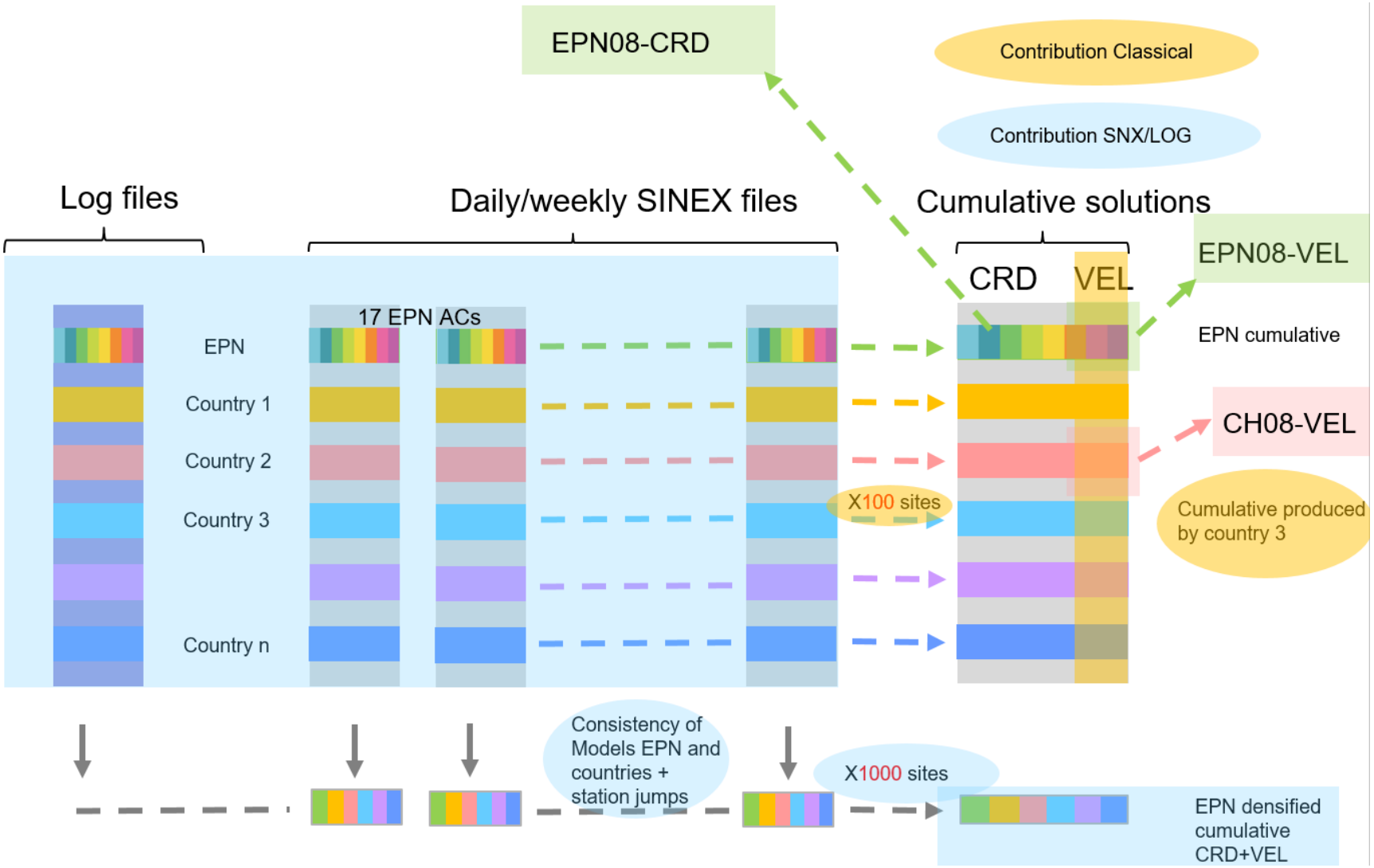
recognising that [redacted] are now available in several areas of Europe

and considering the demand to derive a dense European velocity field which is [redacted] with nationally implemented velocity fields

encourages the continued submission of SINEX files to the EPN Densification Working Group and, from institutions computing velocity fields, to deliver these to the Dense Velocities Working Group.

  - Charter «EUREF Working Group on 'European Dense Velocities'»
    http://euref.eu/TWG/WGdocs/WG-EU-dense-vel-charter-v2.pdf

Densification methods



Motivation and goals

- **Motivation**
  - The individual (and independent) national or regional velocity fields provided for the prototype in the Working Group charter show an overall good agreement
  - Every single contribution is based on elaborated and sophisticated background information with the aim to have the best possible velocity field for the target area (national, regional or global)

- **Goals**
  - To derive a harmonised and comprehensive European dense velocity field from a distributed processing concept making use of the detailed knowledge of the partners
  - To generate a data set for calculating a European velocity grid for reference frame maintenance and geophysical applications

Contributing solutions

Alphabetic list of the solutions

Identifier	Agency	Region	# stations
ALP08	AlpArray	Alps	498
ALPS17	DGFI	Alps	194
ARE08	OLG	Austria	123
BASC08	ARA	Spain	167
CAT08	ICGC	Catalonia	150
CGN08	CEGRN consortium	E-Europe	54
CH08	swisstopo	Switzerland, Europe	199
CH16	swisstopo	Switzerland	211
EGU08	OLG	SE-Europe	181
EPN08	EPN, Kenyeres	Europe	259
ESP08	IGN Spain	Spain	341
GR08	Aristotle Univ. Thessaloniki	Greece	179
HEPOS	Hellenic Cadastre	Greece	60
IGS08	IGN, Altamimi	Global	103
IT08	Univ. Padova	Italy	645
ITRF14	IGN, Altamimi	Global	148
IUG08	OLG	SE-Europe	47
MON08	OLG	SE-Europe	69
NKG03	NKG	Nordic EU countries	556 (grid)
NOQU08	Univ Montpellier	West Alps	76
RGP08	IGN France	France, Europe	544
WALP08	Univ Montpellier	West Alps, Pyrenees	182

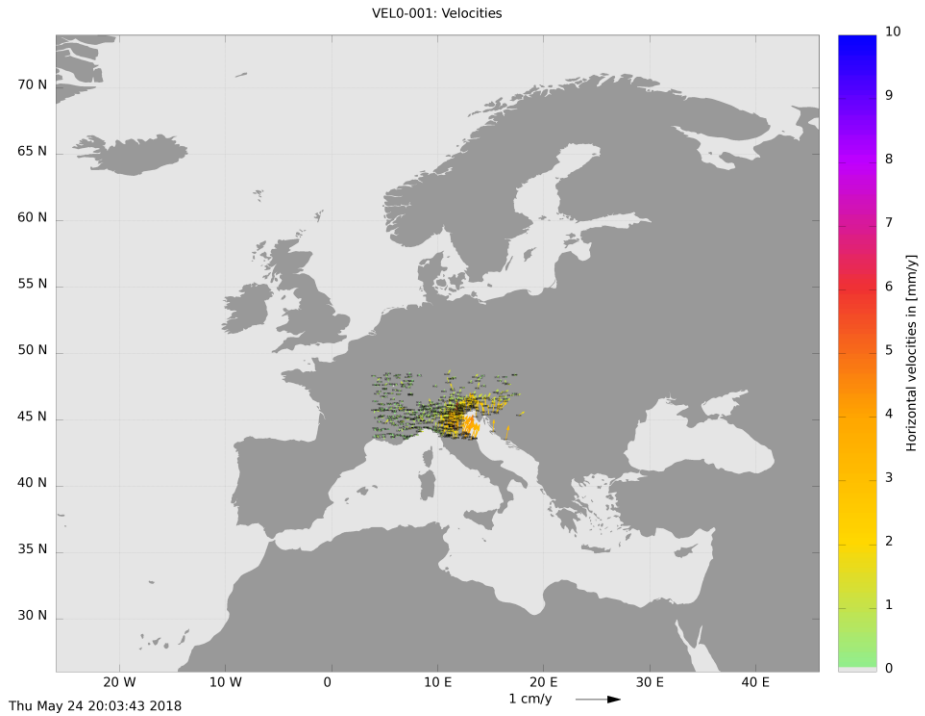
new

new

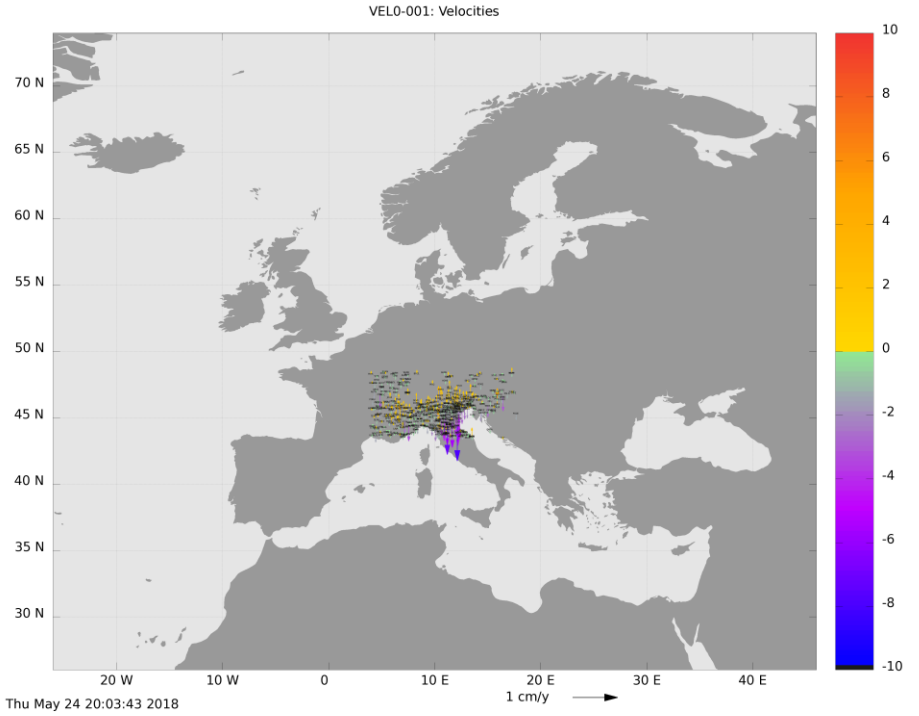
new

- Data set of the Working Group charter + 3 new solutions

The original velocity fields



Horizontal



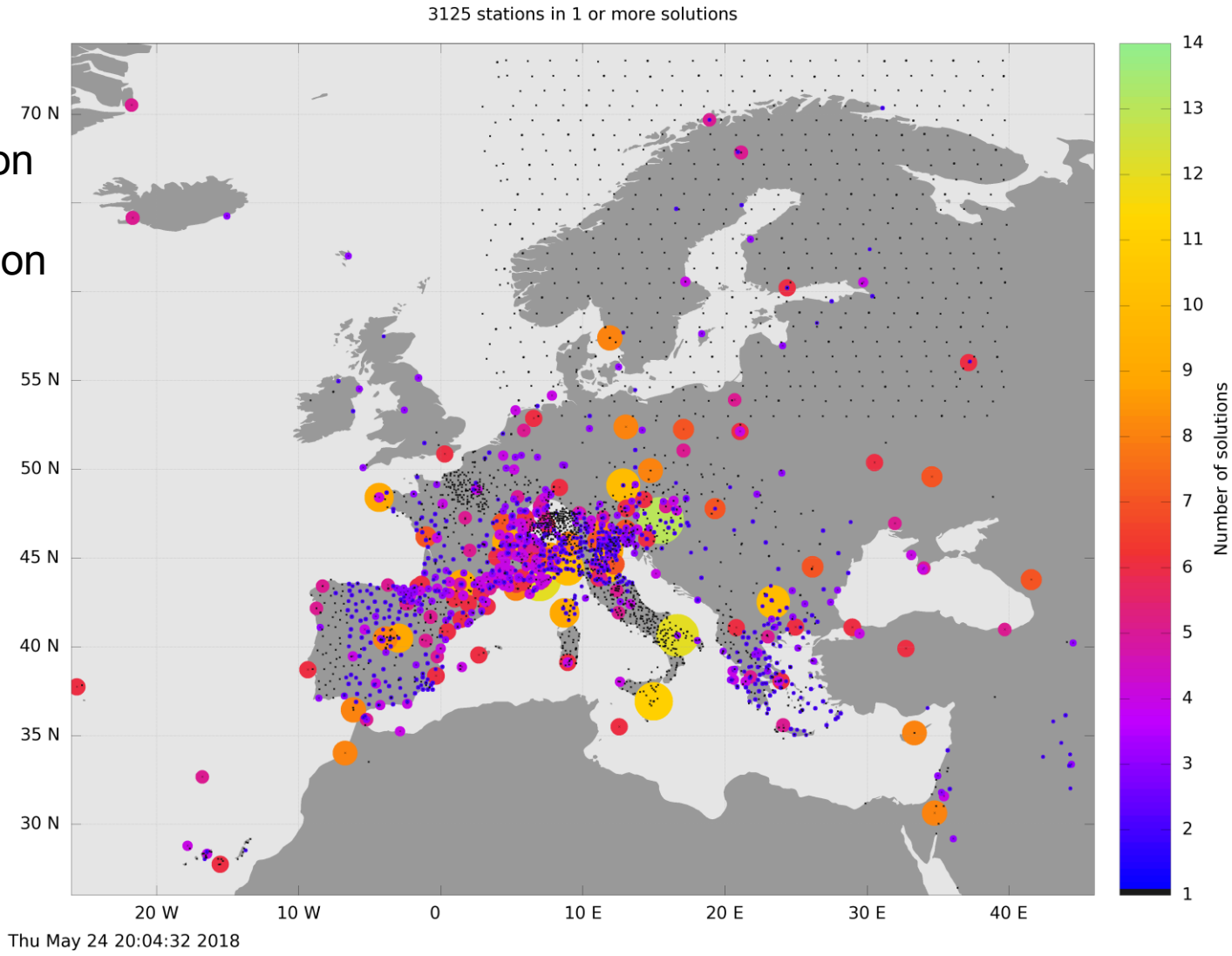
Vertical

- The individual velocity fields should be available in or transformable into a common reference frame (here: ETRF2000)
- Apart from that input velocities stay untouched (only outlier rejections)

Solution overlaps

- Station identification by site name and approximate position (10 km)

```
  1 in  14 or more solutions
  2 in  13 or more solutions
  4 in  12 or more solutions
  5 in  11 or more solutions
  9 in  10 or more solutions
 16 in   9 or more solutions
 27 in   8 or more solutions
 38 in   7 or more solutions
 81 in   6 or more solutions
126 in   5 or more solutions
218 in   4 or more solutions
392 in   3 or more solutions
934 in   2 or more solutions
3125 in  1 or more solutions
```



First results from the combination

Outlier rejection steps

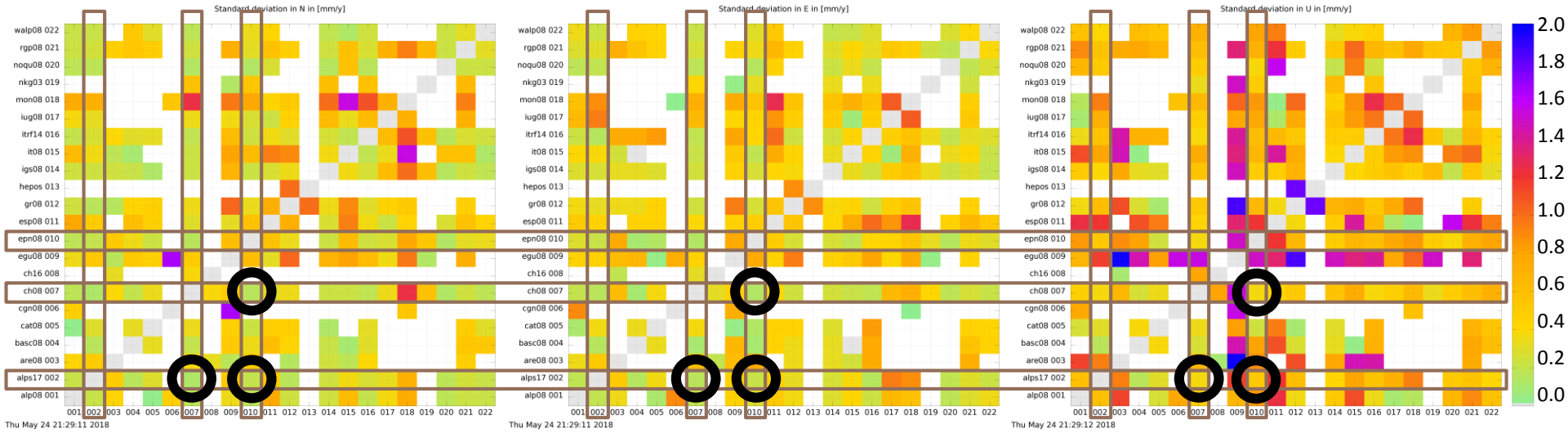
1. **Format overflow**
   - igs08 (8)

2. **Visual inspection and a priori values (e.g. 3-d vel. = 0)**
   - alp08 (1), basc08 (1), cat08 (2), egu08 (4), igs08 (1), it08 (198), noqu08 (1), rgp08 (175), walp08 (1)

3. **First residual screening (9 mm/y or 3·σ w.r.t. median)**
   - are08 (12), basc08 (1), cat08 (1), egu08 (43), epn08 (3), esp08 (5), gr08 (70), hepos (28), igs08 (2), it08 (2), itrf14 (3), iug08 (6), mon08 (7), rgp08 (5)

4. **Second residual screening (3 mm/y w.r.t. median)**
   - alp08 (3), are08 (67), basc08 (6), cat08 (1), cgn08 (4), egu08 (12), epn08 (2), esp08 (6), gr08 (10), hepos (1), it08 (6), itrf14 (1), iug08 (2), mon08 (5), rgp08 (1), walp08 (1)

Cross validation of the individual inputs



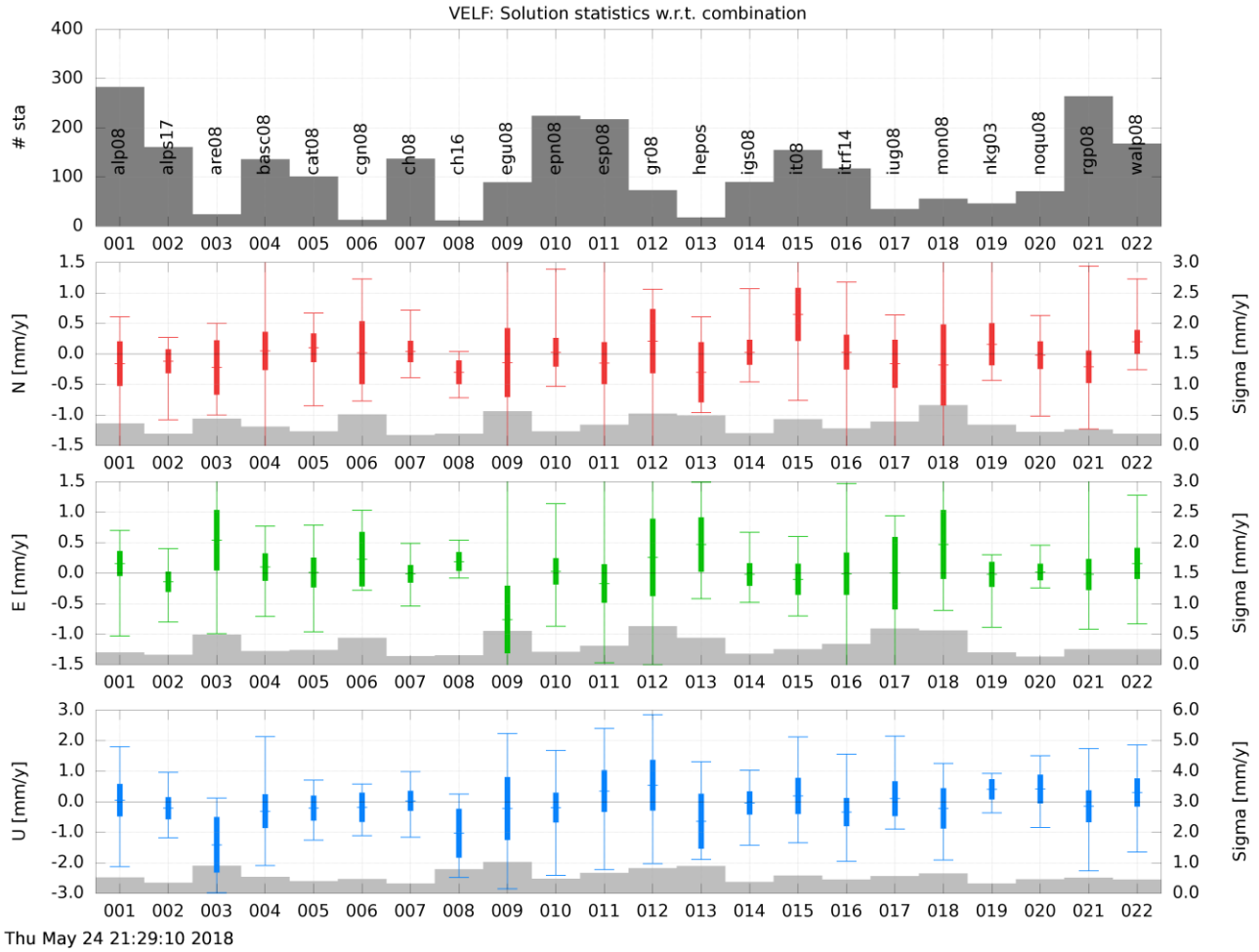
North **East** **Up**

Examples mm/yr

# SOLUTION 1	- SOLUTION 2	NUM	MEAN_N	SDEV_N	MEAN_E	SDEV_E	MEAN_U	SDEV_U
002 alps17	007 ch08	49	-0.07	0.11	-0.07	0.15	-0.10	0.36
002 alps17	010 epn08	52	-0.08	0.19	-0.09	0.20	0.13	0.51
007 ch08	010 epn08	79	-0.01	0.16	0.03	0.12	0.23	0.37

- The solutions agree (standard deviation) between
  - 0.2 mm/y and 0.8 mm/y horizontally
  - 0.4 mm/y and 1.6 mm/y vertically

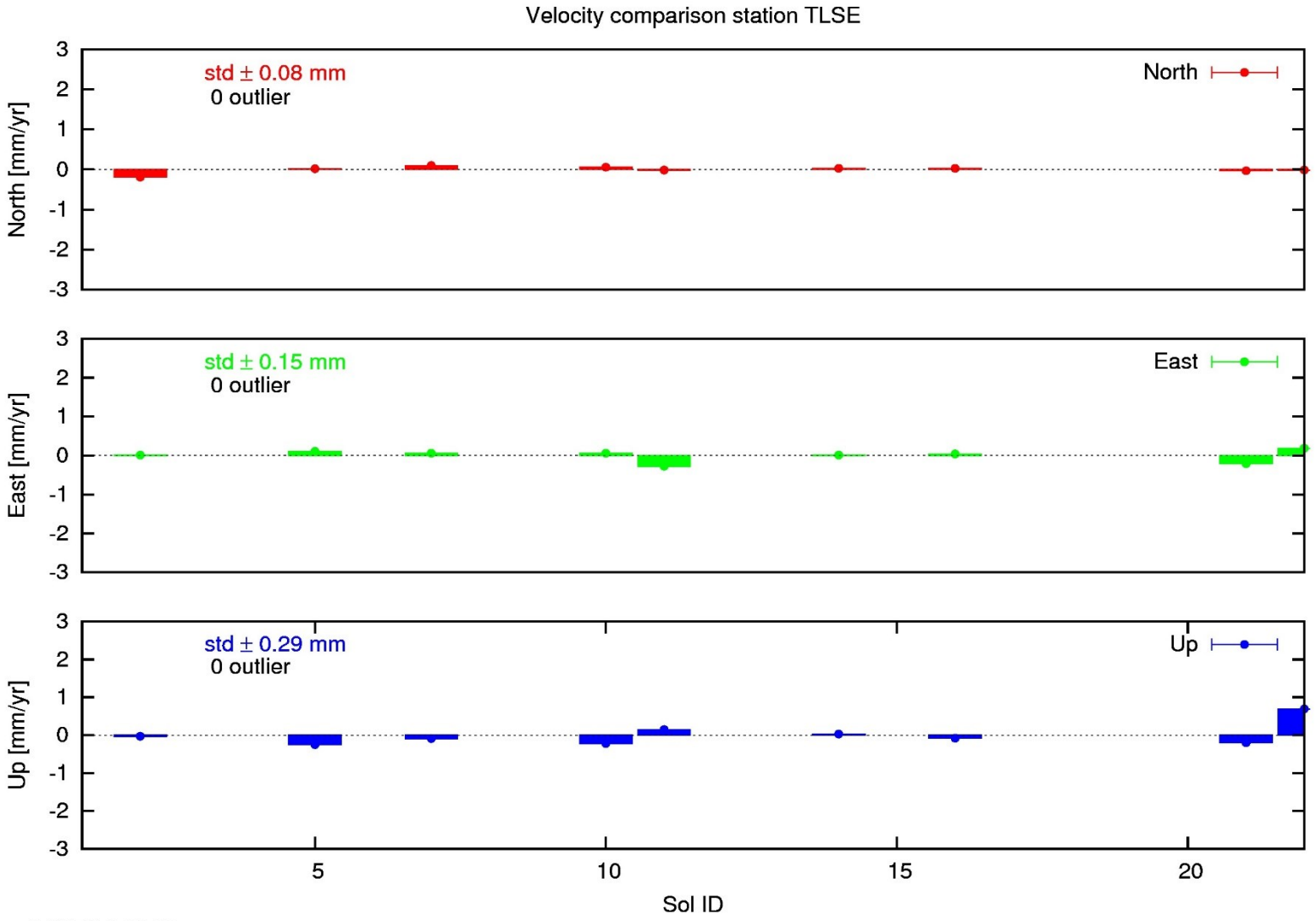
Solution statistics w.r.t. the combination



In general no significant biases:
→ All contributions with sufficient accuracy in ETRF2000 (only exceptions: egu08, it08)

- Number of stations in two or more solutions, minimum, maximum, mean and standard deviation of the residuals w.r.t. the combination

Example of a very good station



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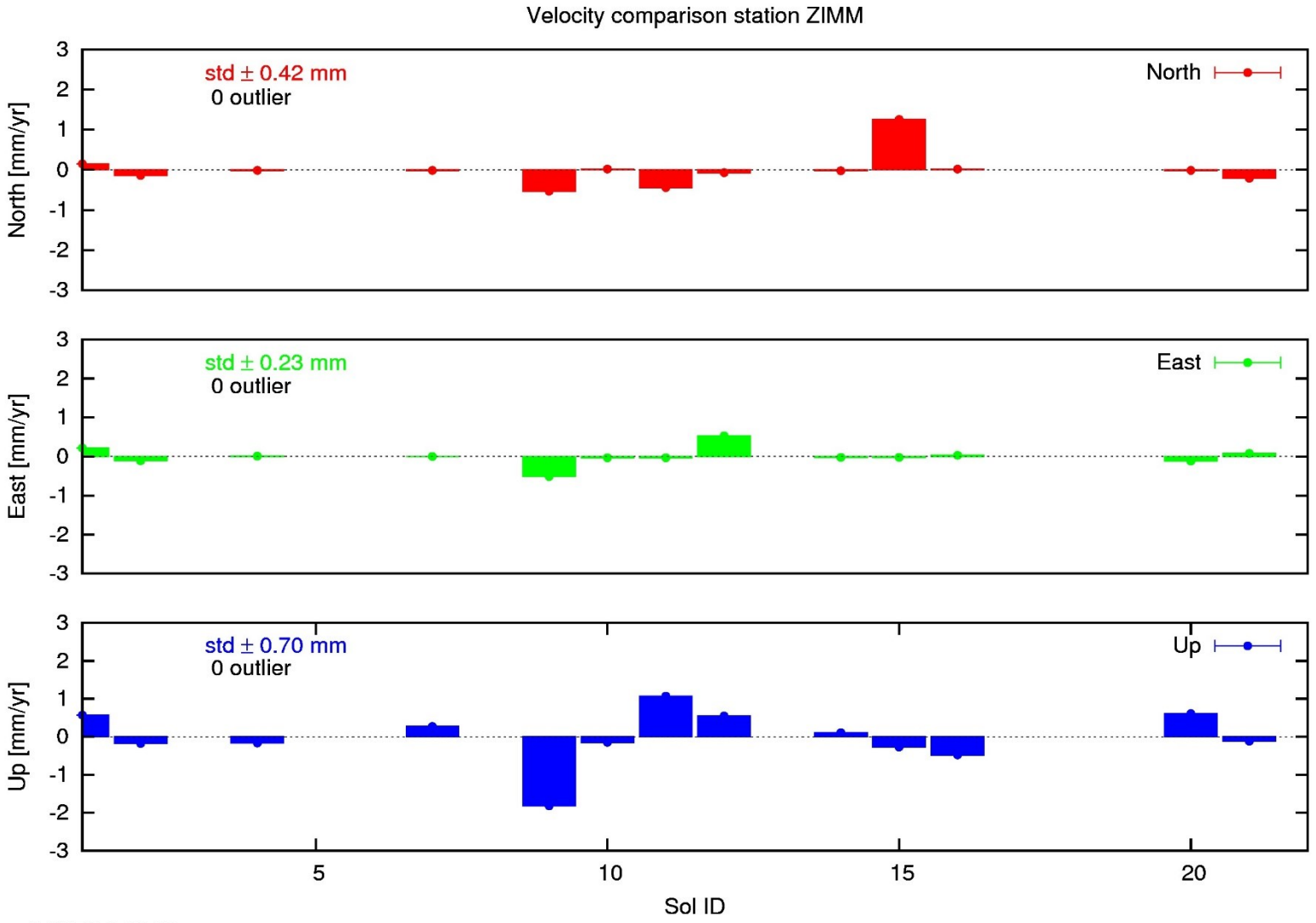
Example of a good station



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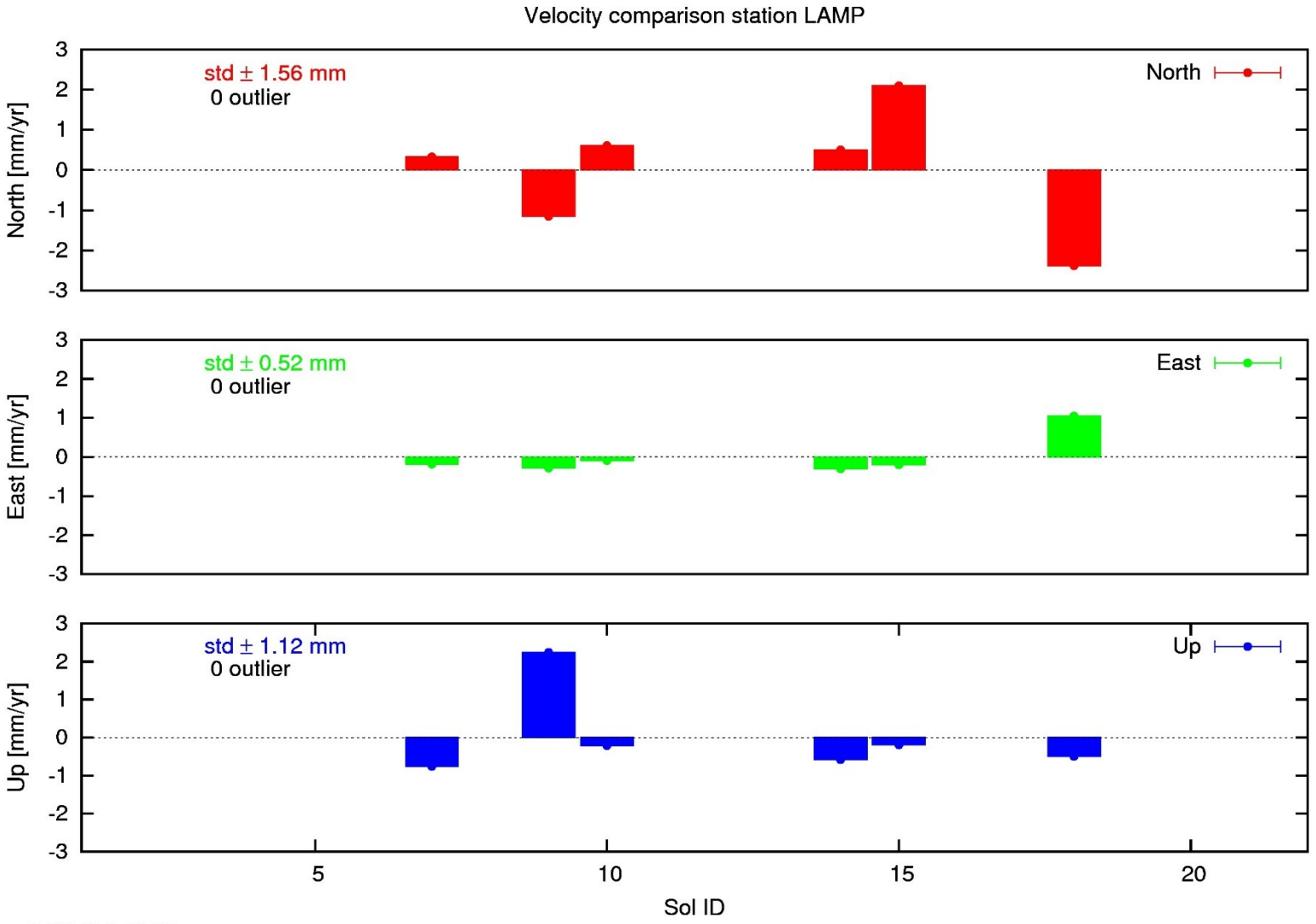
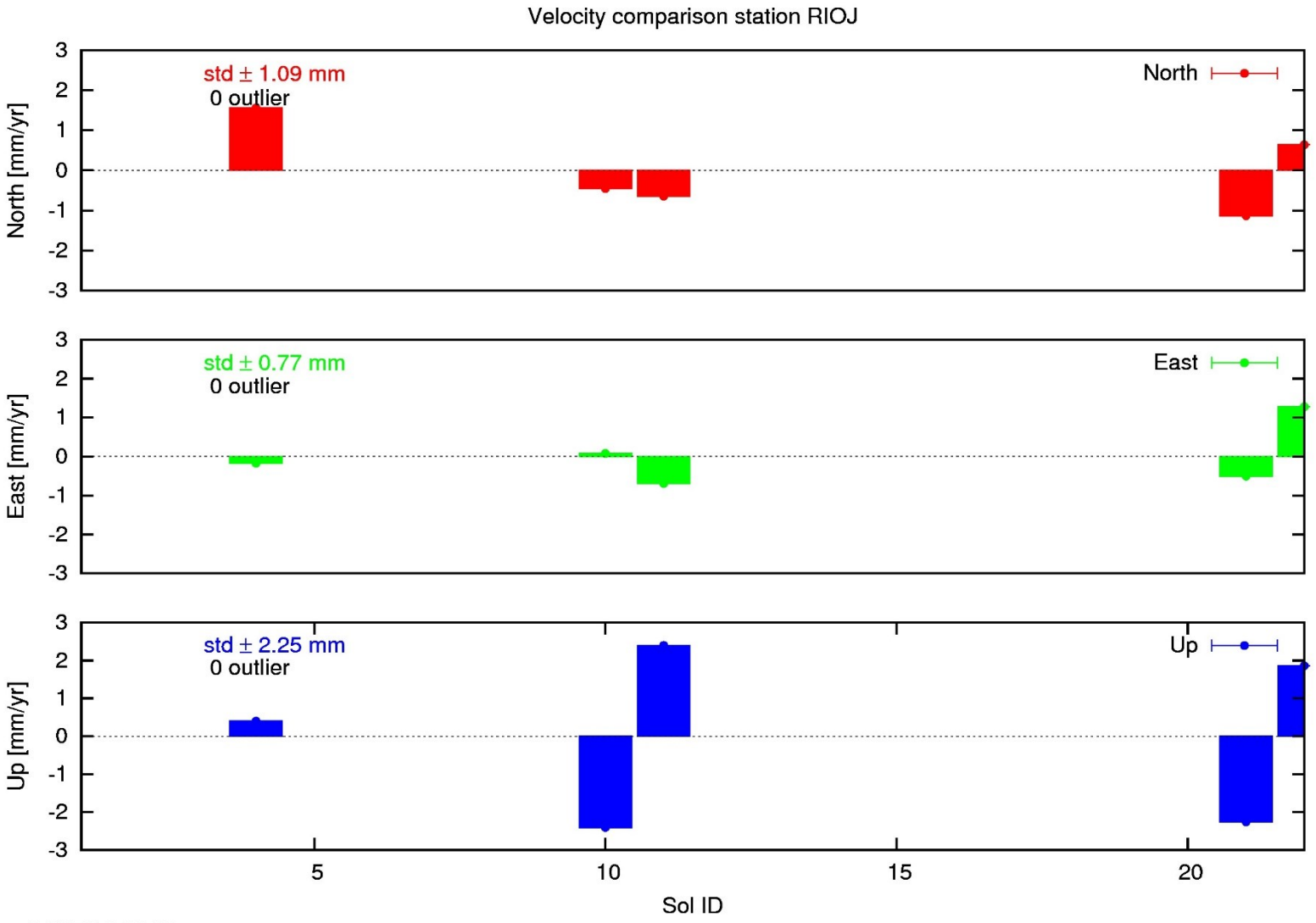
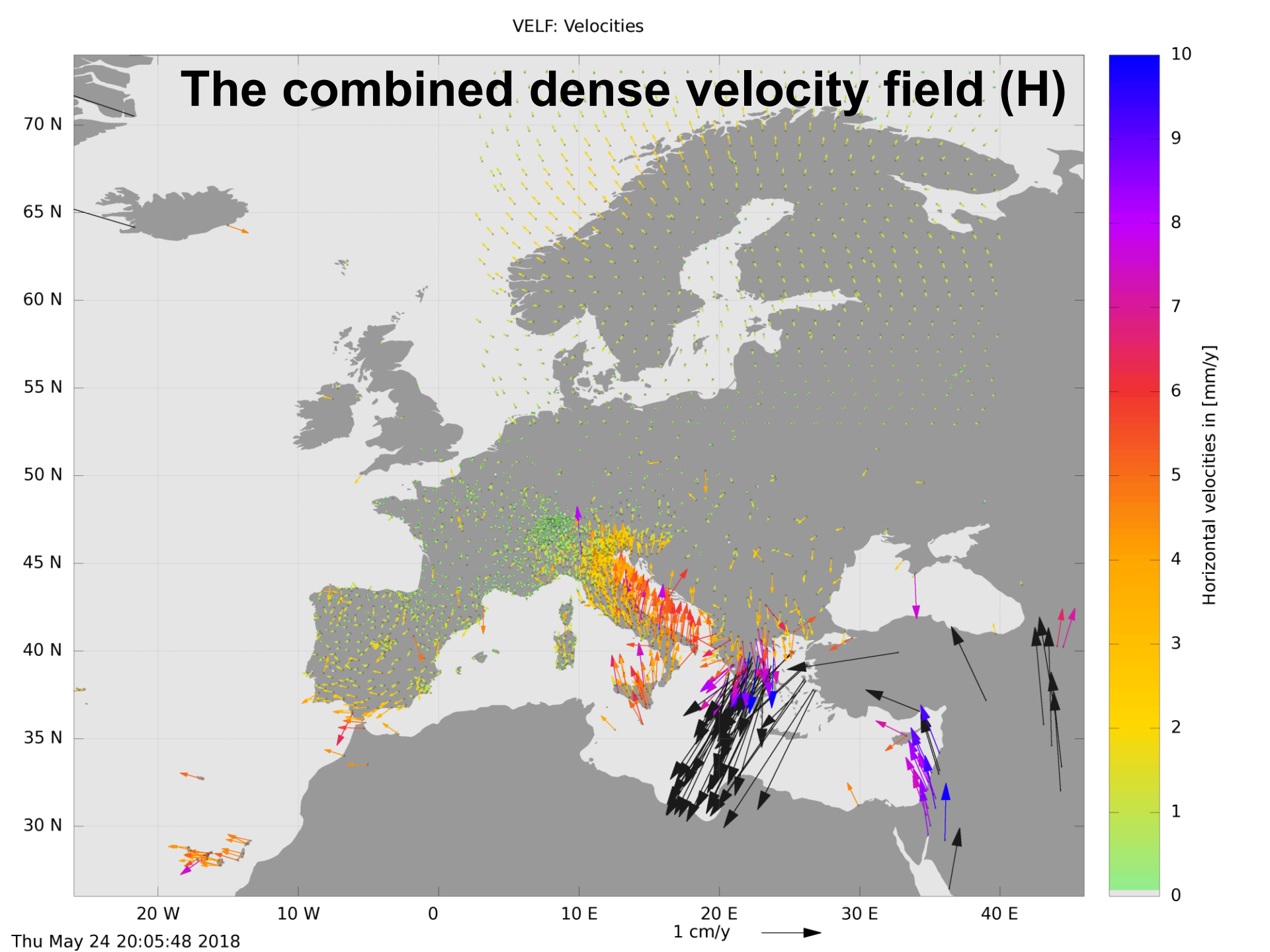
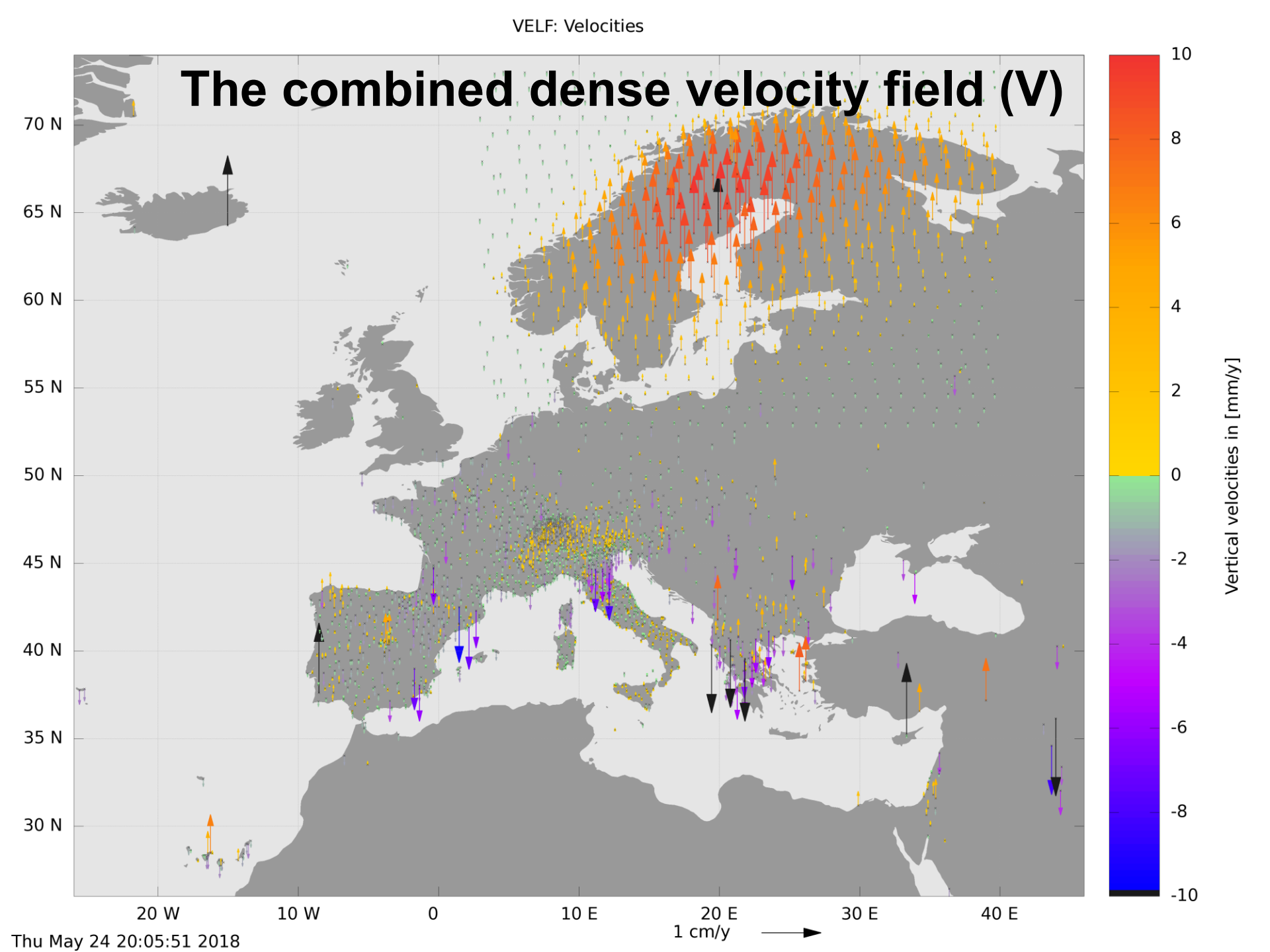
Example of a less coinciding station



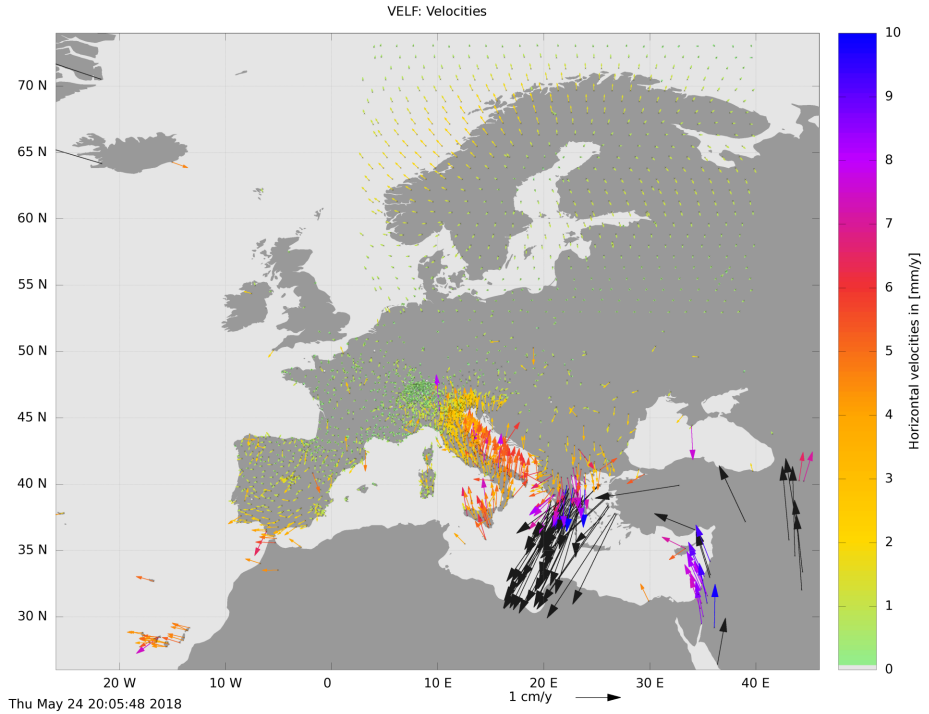
Example of a less coinciding station



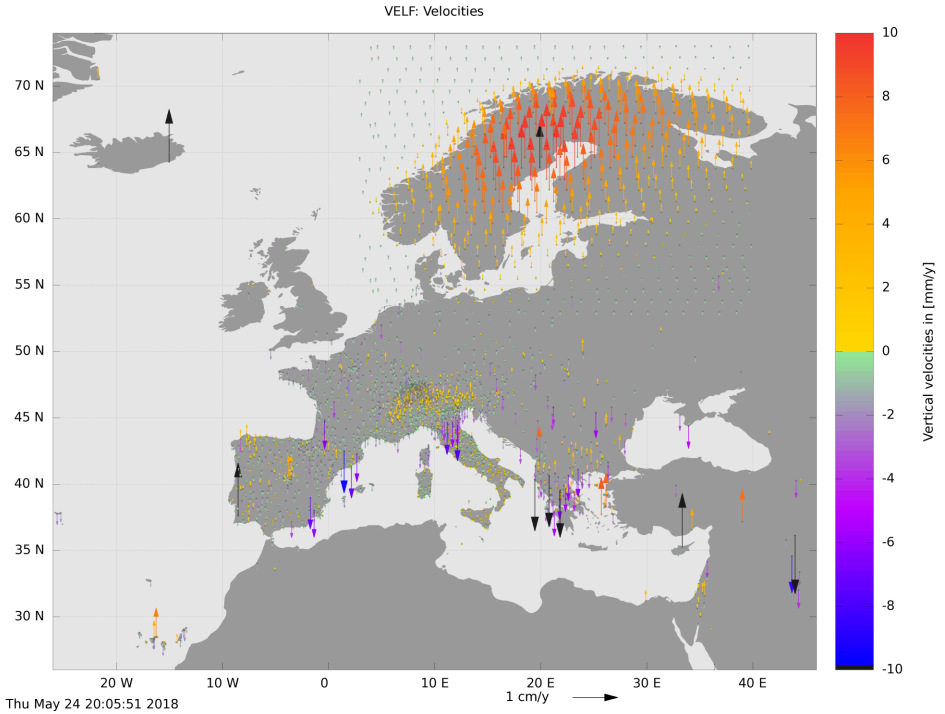

VELF: Velocities
The combined dense velocity field (H)
70 N
65 N
60 N
55 N
50 N
45 N
40 N
35 N
30 N
20 W
10 W
0
10 E
20 E
30 E
40 E
1 cm/y
Thu May 24 20:05:48 2018
Horizontal velocities in [mm/y]
0
1
2
3
4
5
6
7
8
9
10


VELF: Velocities
The combined dense velocity field (V)
70 N
65 N
60 N
55 N
50 N
45 N
40 N
35 N
30 N
20 W
10 W
0
10 E
20 E
30 E
40 E
1 cm/y
Thu May 24 20:05:51 2018
10
8
6
4
2
0
-2
-4
-6
-8
-10
Vertical velocities in [mm/y]

The combined dense velocity field



Horizontal

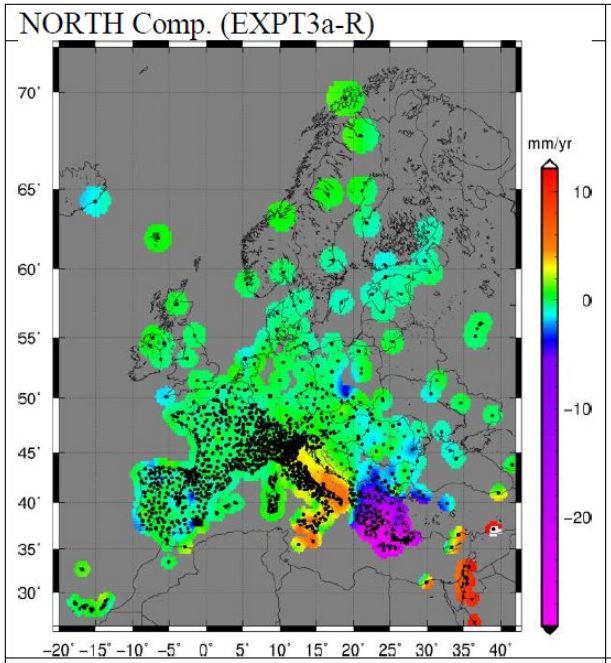


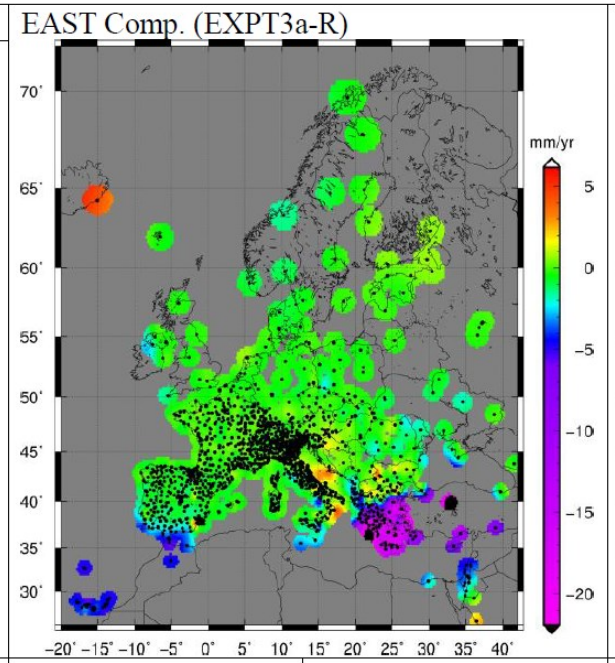
Vertical

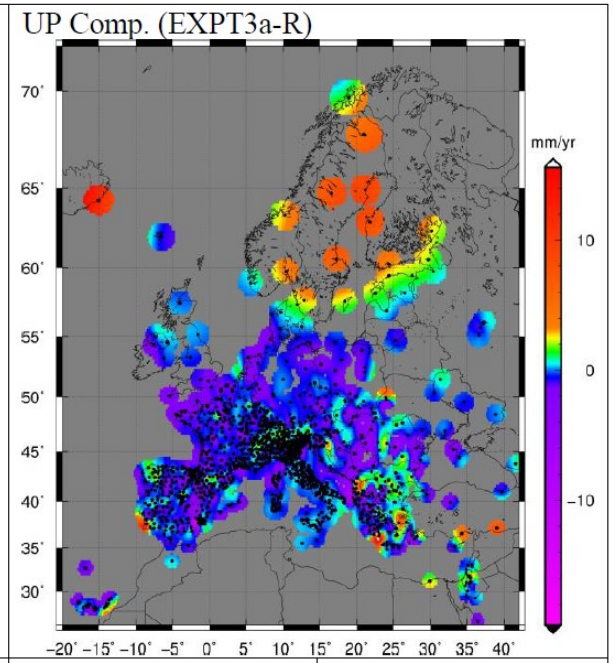
- A comprehensive dense velocity field over Europe can be realised
- Distortions of the European plate and orogenic or isostatic uplifts are visible (input for WG “Deformation Models” and for geophysical studies)
- Locally unstable (misbehaving) sites can be identified

A European velocity grid

- First results of a European velocity model
- S. Bitharis, C. Pikridas, A. Fotiou and D. Rossikopoulos (@topo.auth.gr)







STATISTICS (200 control points)	North [mm]	East [mm]	Horizontal	Vertical
MIN	-12.31	-5.69	0.03	-9.71
MAX	4.64	1.46	13.56	13.35
AVERAGE	0.03	-0.10	**0.90**	**0.13**
STD	1.27	0.83	**1.23**	**1.93**

Summary

- The EUREF Working Group on “European Dense Velocities” follows the classical approach of combining individual, dense velocity fields
- The 22 contributions including the NKG grid were successfully combined conserving the inner geometry of the inputs to a large extent
- Combination results identify a small percentage of outliers – information exchange need to be established within the Working Group
- The input velocity fields are with sufficient accuracy in the European Terrestrial Reference Frame ETRF2000
- Inter-plate velocities of the European plate and orogenic or isostatic uplifts are clearly visible
- First grid calculations are promising

Thank you for your attention!

- **The 20 Working Group members from the WG charter**: Baron A, Baroni L, Bitharis S, Brockmann E, Caporali A, Fotiou A, Franke P, Gianniou M, Lidberg M, Mathis E-R, Pikridas C, Rossikopoulos D, Serpelloni E, Sobrino J, Söhne W, Stangl G (retired), Vernant P, De Vargas M, Völksen C, Zurutuza J

- Currently 38 members in the mailing list

- **Splinter Meeting**:
  Today at 16:00
  All interested persons are welcome