Contributo das redes de estações GNSS de observação contínua para as geociências

João Agria Torres

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TÓPICOS

– *Sobre a geodesia satelitária e os GNSS*

– *Alguns contributos para as geociências*

– *Considerações finais e agradecimentos*

Philosophiæ naturalis principia mathematica

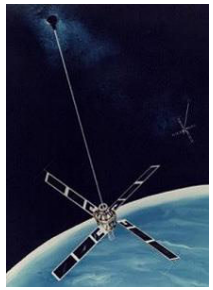
1678

De la Terre à la Lune

1865

Sputnik I

Satélites geodésicos

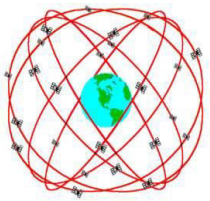


1957

1960

Satellite Laser Ranging

1970



GPS

1980

- GLONASS
- IUGG 1983
- EUREF (IUGG 1987)

- TANGO (1988)
- EUREF 89

1980

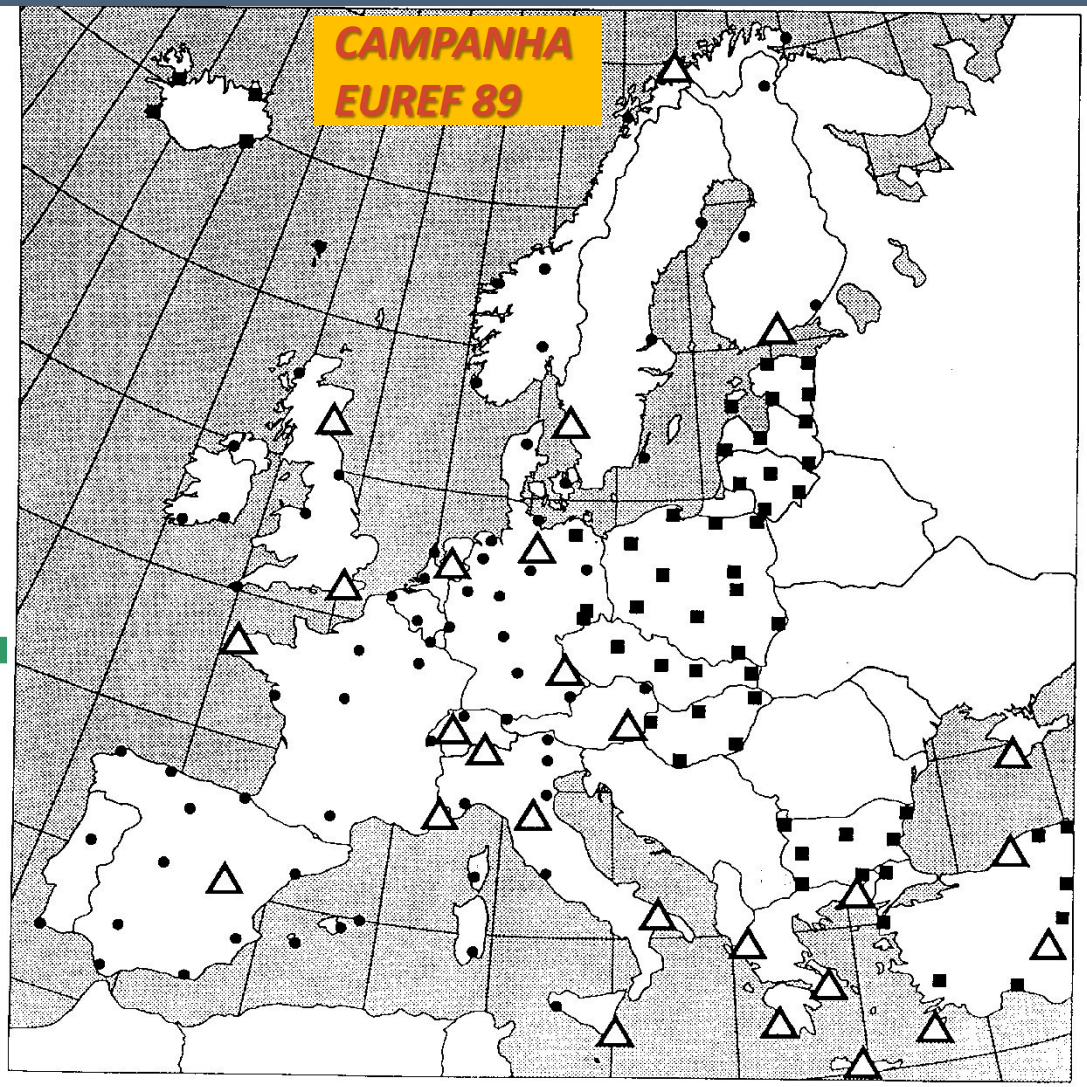
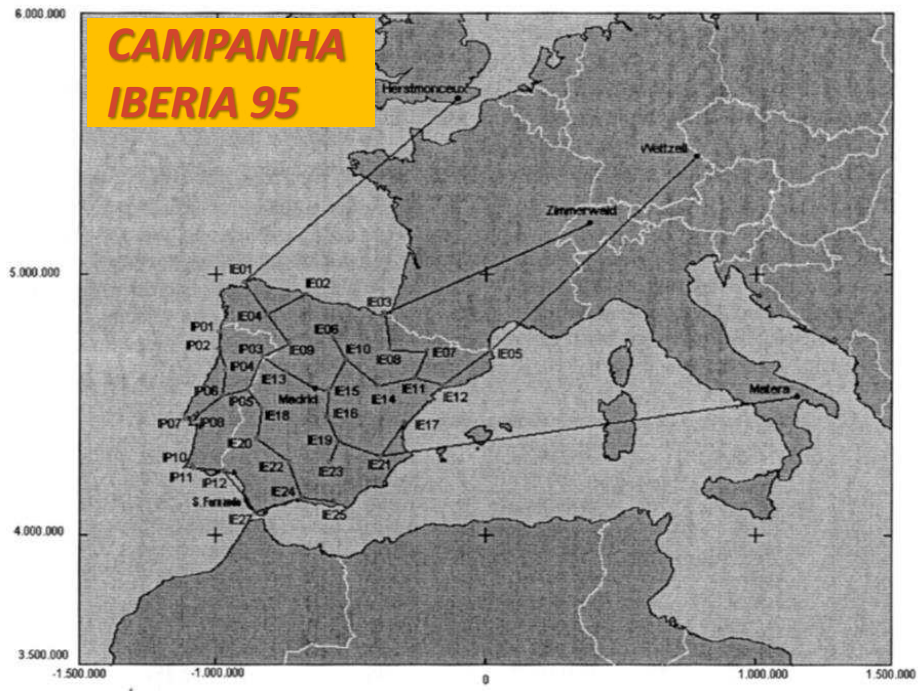


Figura 1 — Estações EUREF

△ — Estação SLR ou VLBI • Estação EUREF89

GNSS: DESENVOLVIMENTOS – CONSOLIDAÇÃO



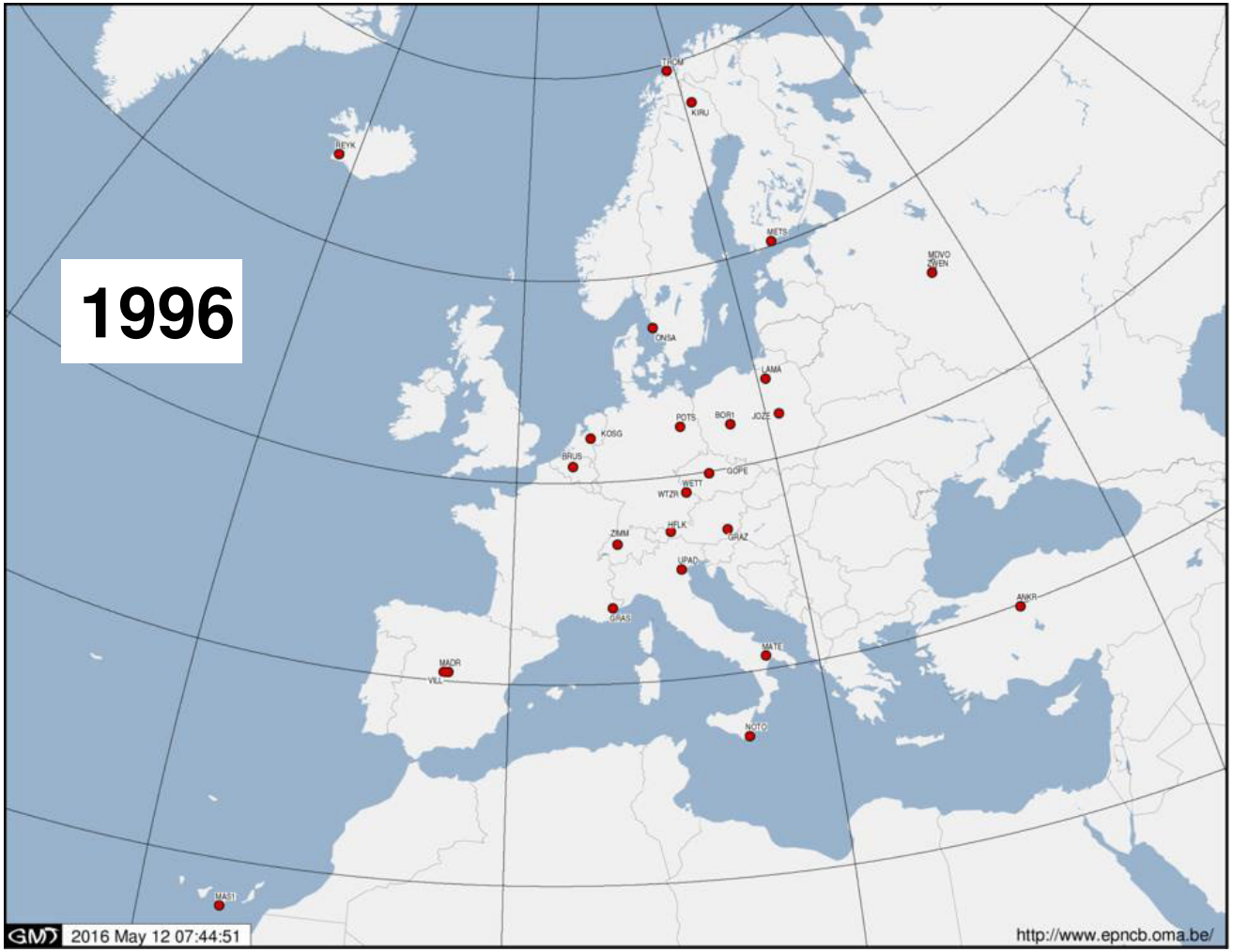
- *IGS (1994)*
- *EPN (1996)*
- *TENDÊNCIAS EVOLUTIVAS DA CARTOGRAFIA (1992)*

- *EUROGAUGE (1991)*
- *IBERIA 95*

1990 **2000**

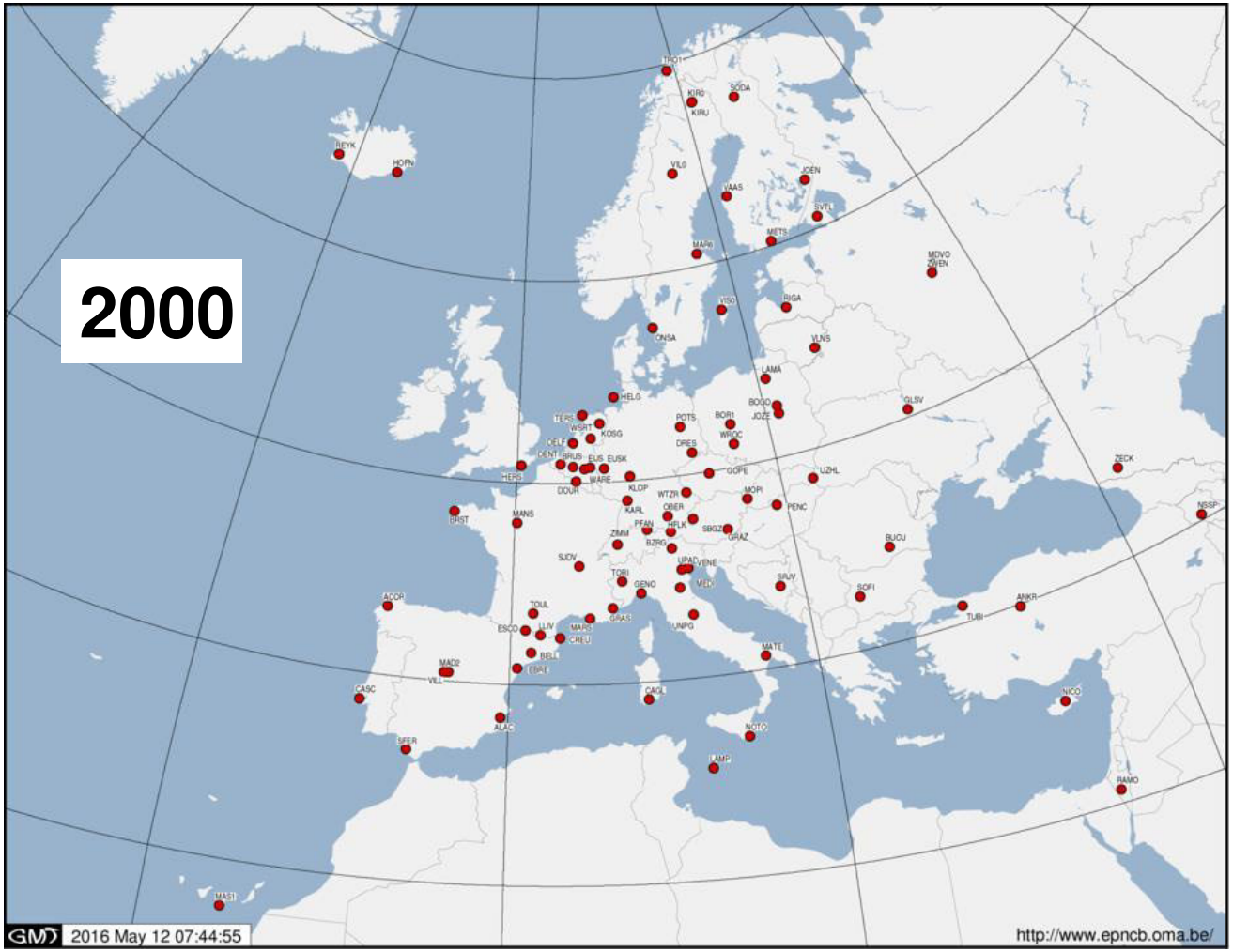
CASCAIS NA EPN

(Bruyninx, C., 2017)



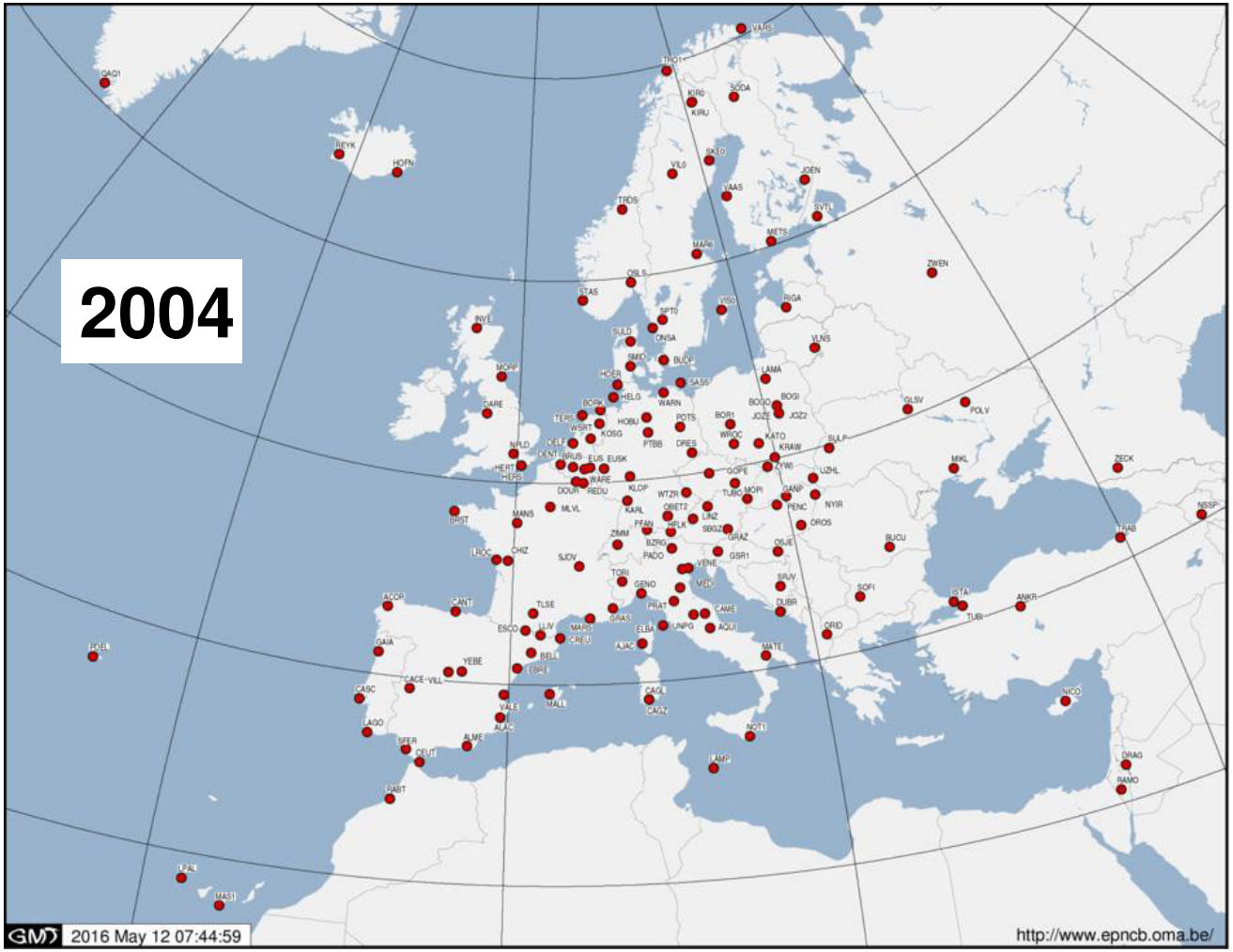
CASCAIS NA EPN

(Bruyninx, C., 2017)



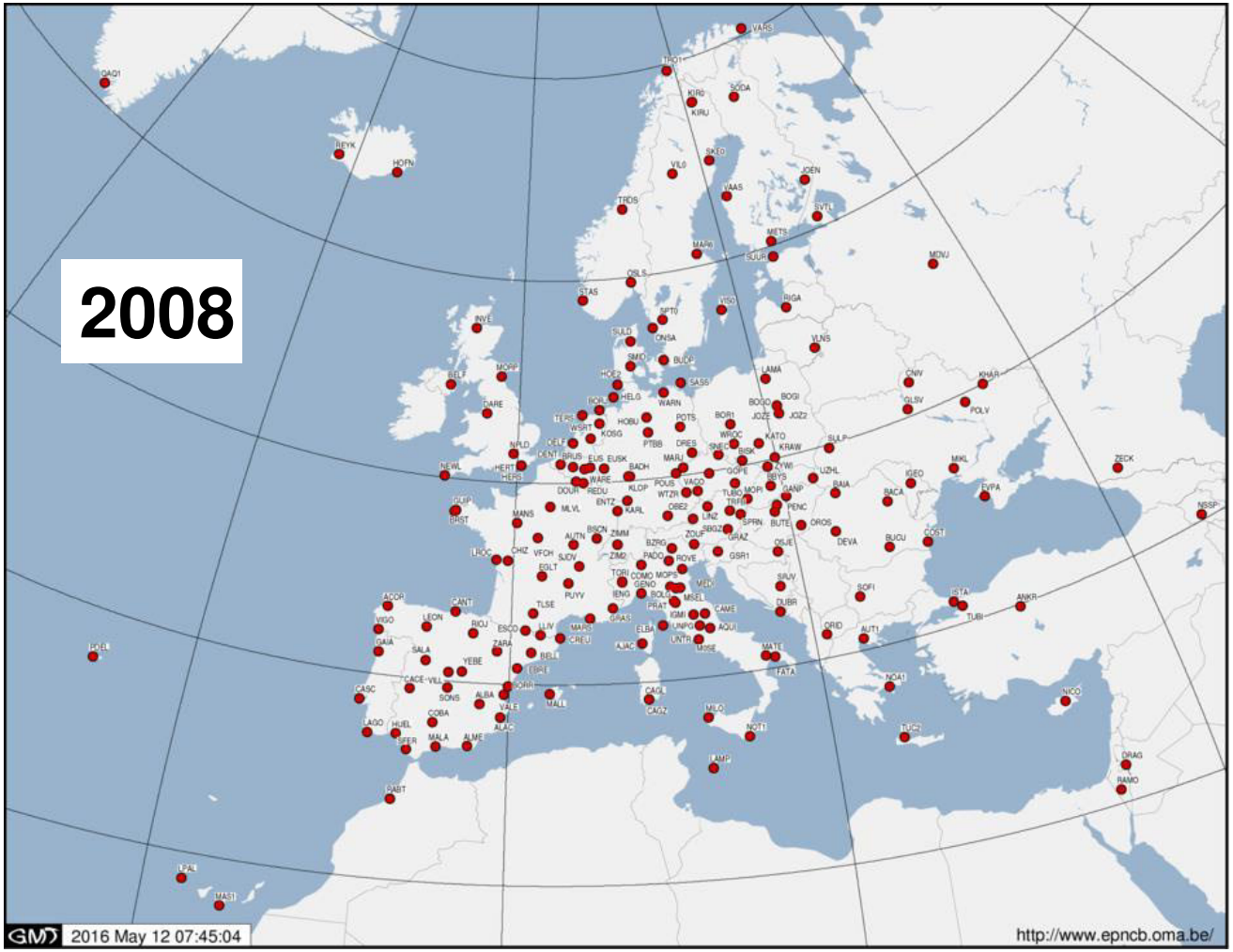
CASCAIS NA EPN

(Bruyninx, C., 2017)



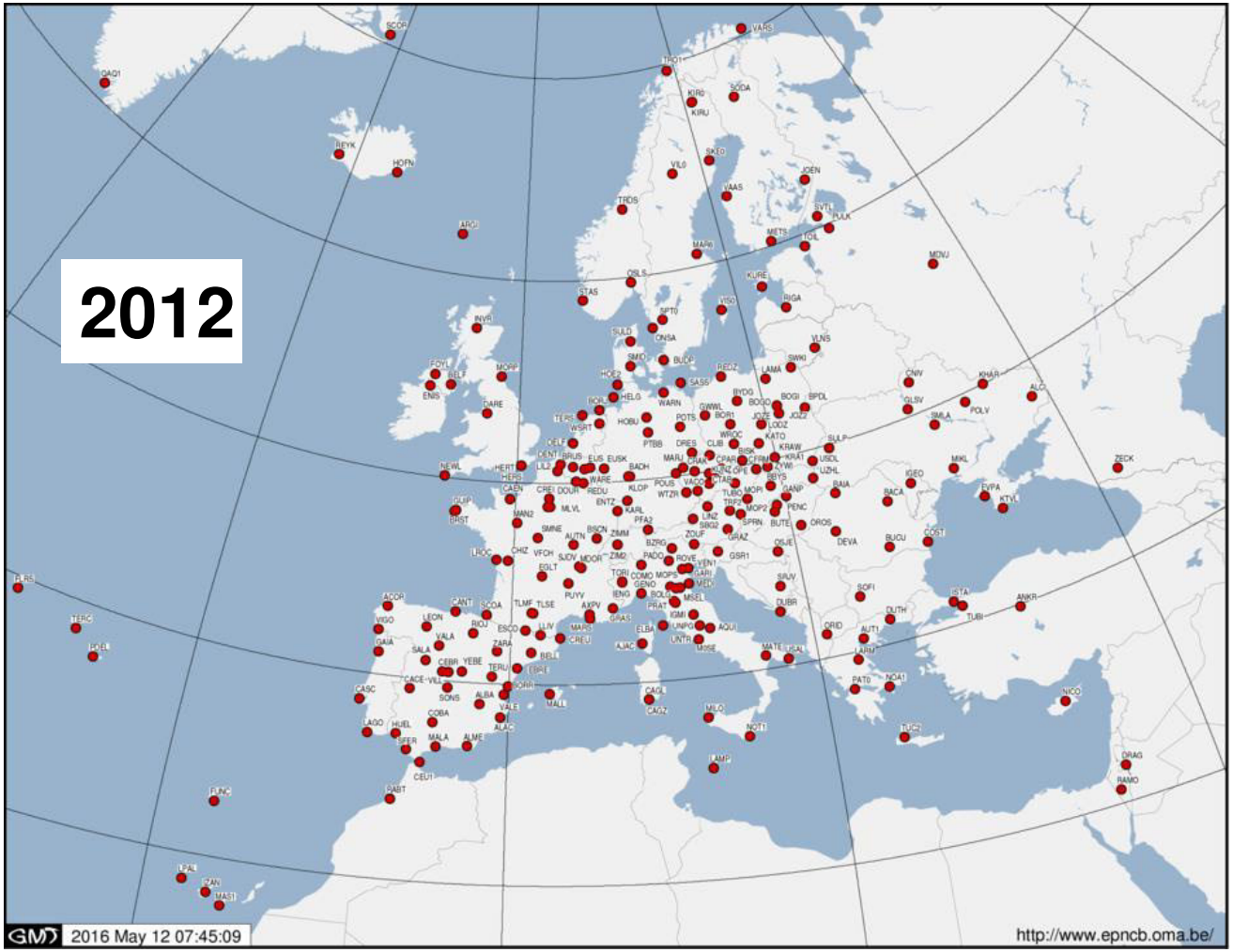
CASCAIS NA EPN

(Bruyninx, C., 2017)



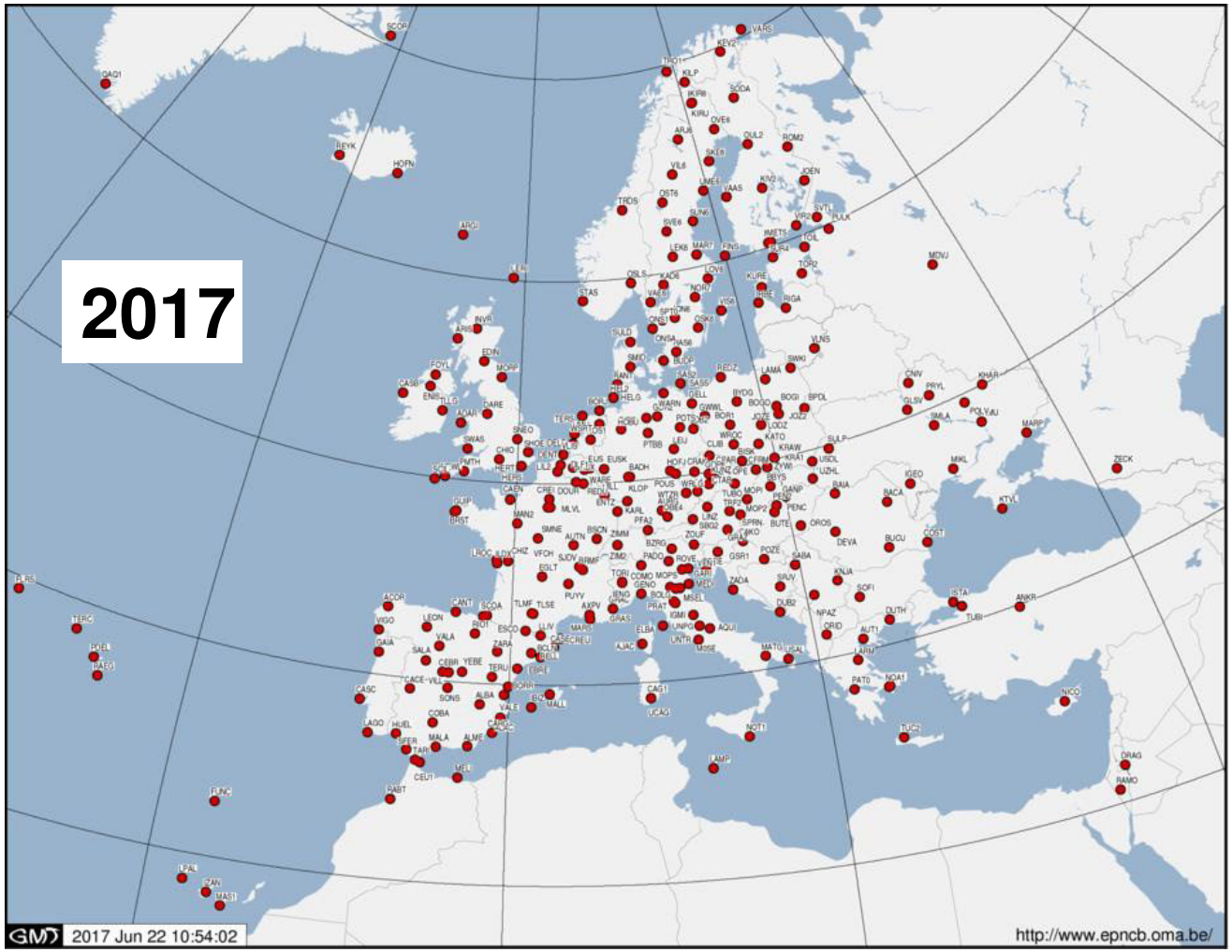
CASCAIS NA EPN

(Bruyninx, C., 2017)



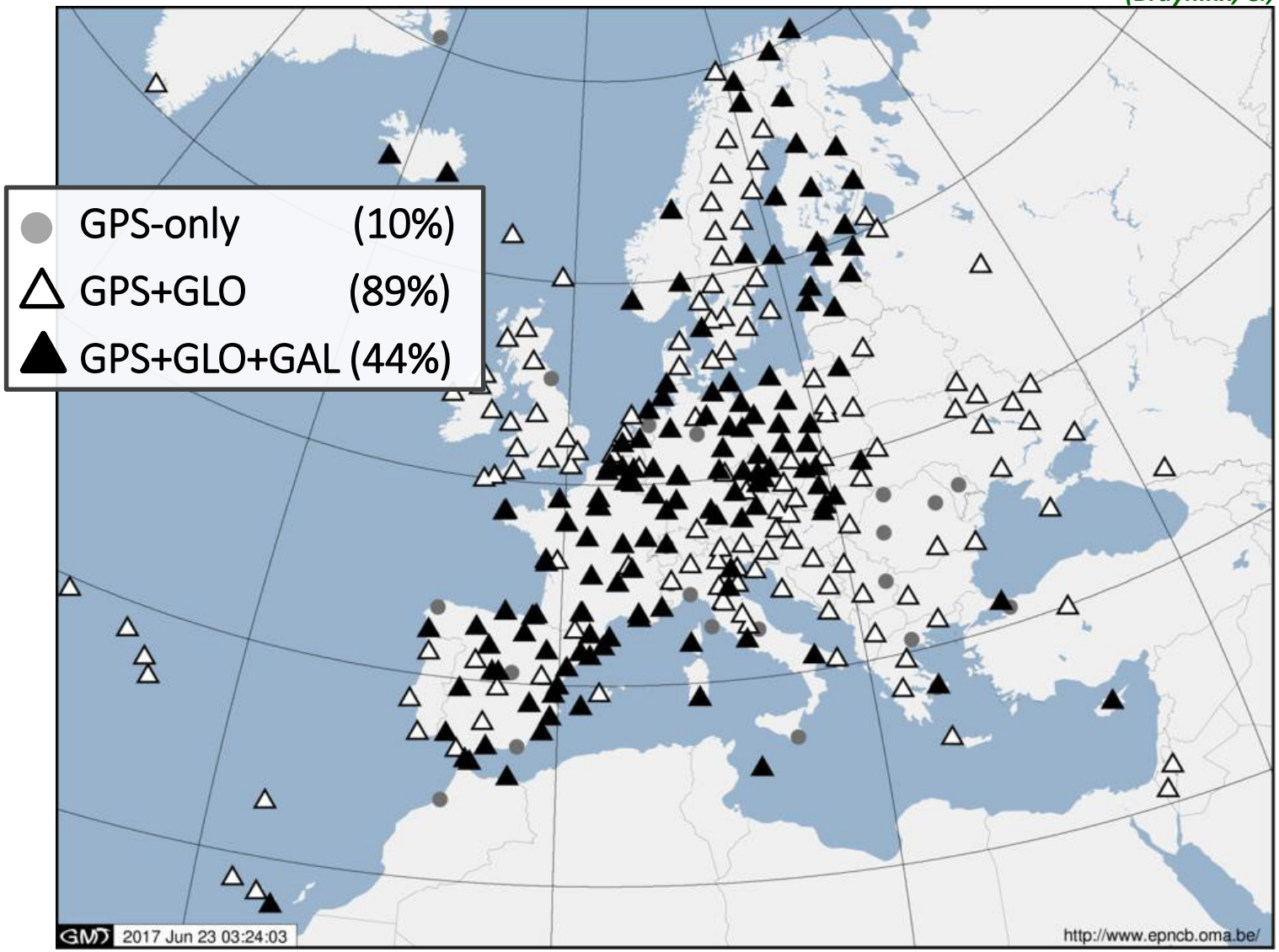
CASCAIS NA EPN

(Bruyninx, C., 2017)



CASCAIS NA EPN

(Bruyninx, C., 2017)



CASC data provided to EUREF

(Bruyninx, C., 2017)

RINEX V2.11 - GPS+GLO

DAILY

Data centres	Online	Last data	Availability
EPNCB (historical)	✔	090/2017	N/A
BEV	✔	172/2017	100%
BKGE	✔	172/2017	100%

HOURLY

Data centres	Online	Last data	Availability	Latency
BEV	✔	173/2017 (O)	99%	59%
BKGE	✔	173/2017 (O)	100%	83%

RINEX V3.02 - GPS+GLO

DAILY

Data centres	Online	Last data	Availability
EPNCB (historical)	✔	090/2017	N/A
BEV	✔	172/2017	100%
BKGE	✔	172/2017	100%

HOURLY

Data centres	Online	Last data	Availability	Latency
BEV	✔	173/2017 (O)	100%	55%
BKGE	✔	173/2017 (O)	100%	77%

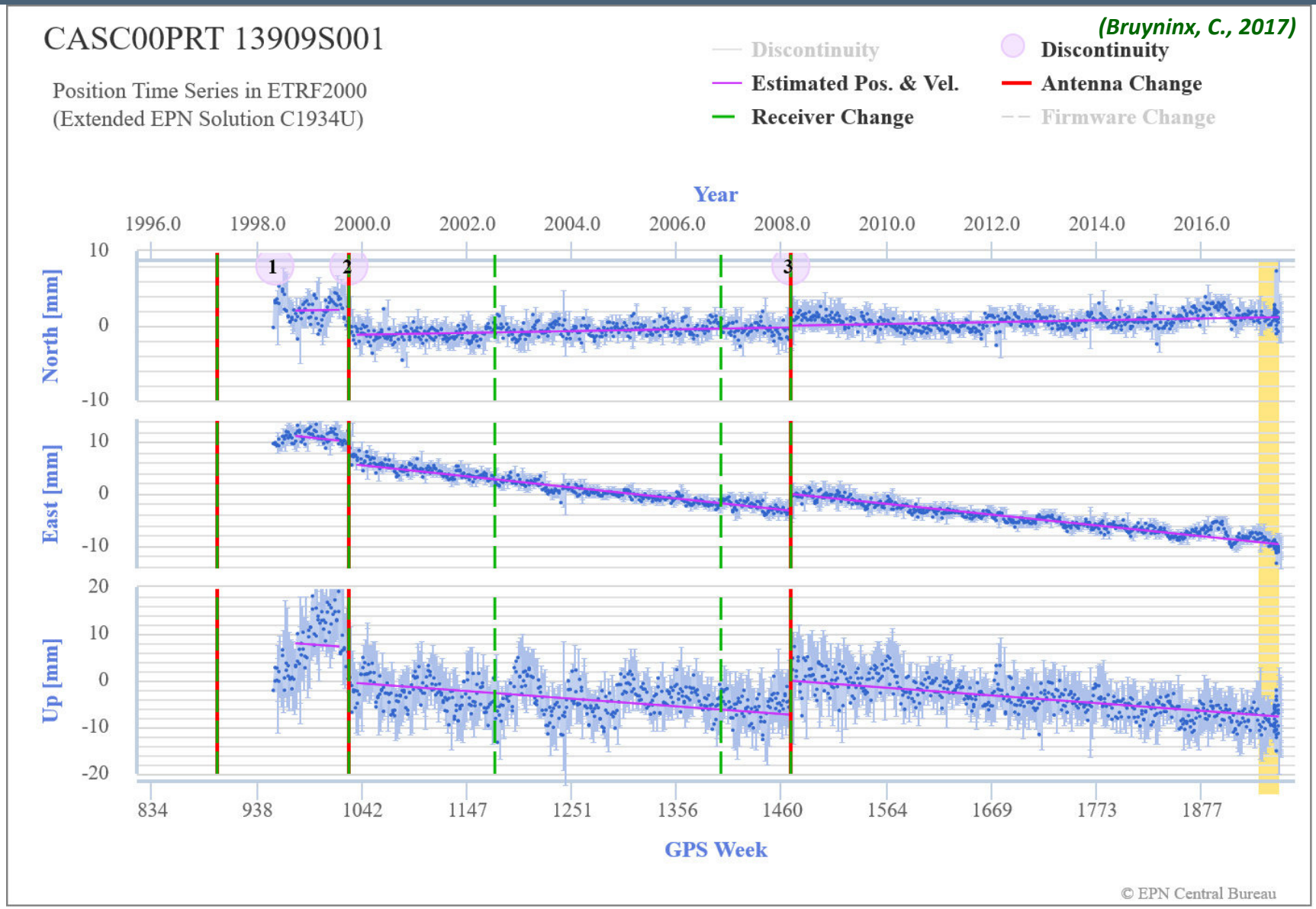
Daily and Hourly Latency Plots

REAL-TIME (RTCM 3.0, RTCM 3.1)

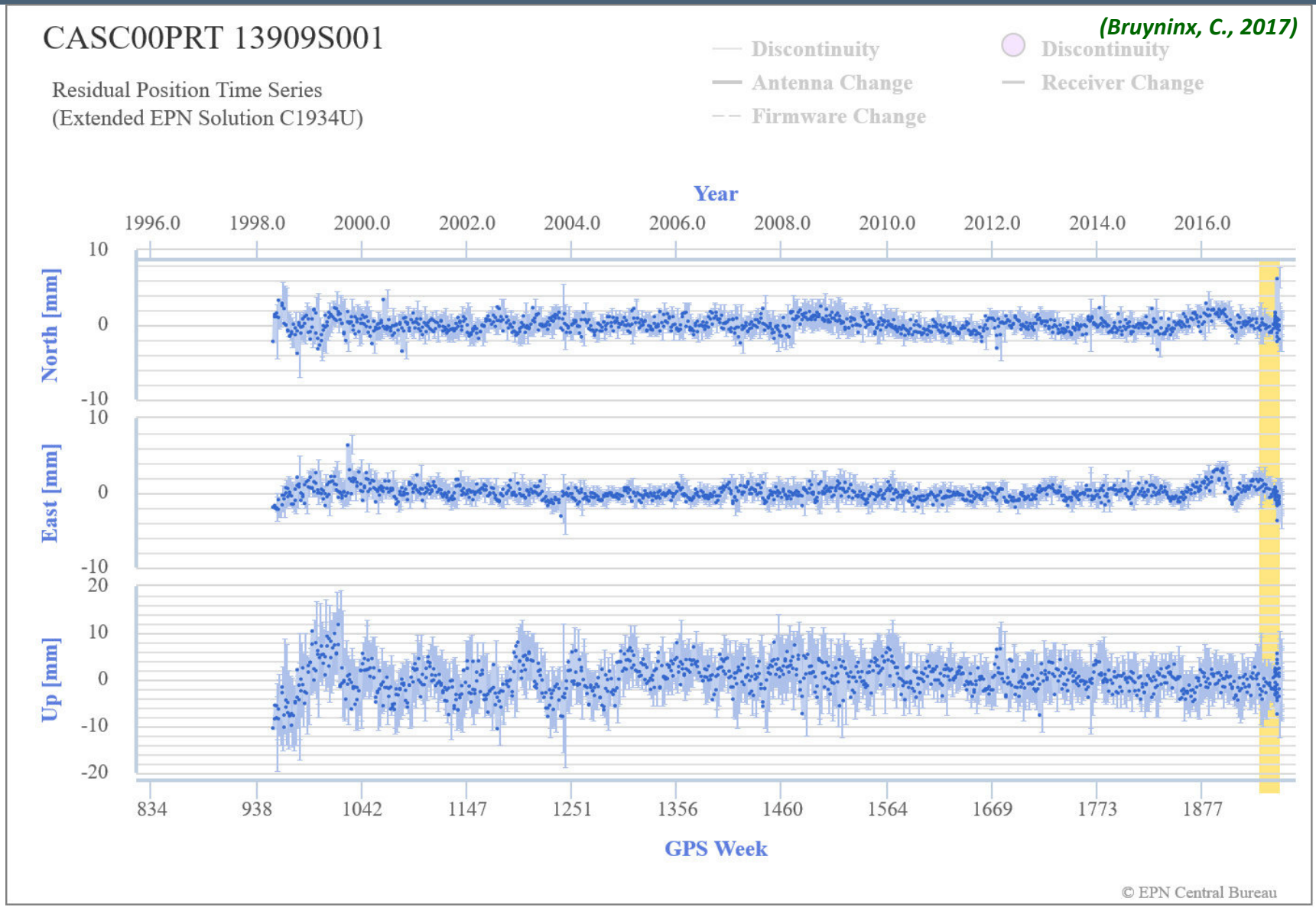
CASC0 available from :

- ✔ ASI (broadcaster, registration) - RTCM 3.0 (last data on 2015-09-16 07:55 UTC) : 1004(1),1006(60),1008(60),1012(1),1013(60),1033(60)
- ✔ BKG (broadcaster, registration) - RTCM 3.1 : 1004(1),1006(60),1008(60),1012(1),1013(60),1033(60)
- ✔ ROB (broadcaster, registration) - RTCM 3.1 : 1004(1),1006(60),1008(60),1012(1),1013(60),1033(60)

CASCAIS NA EPN

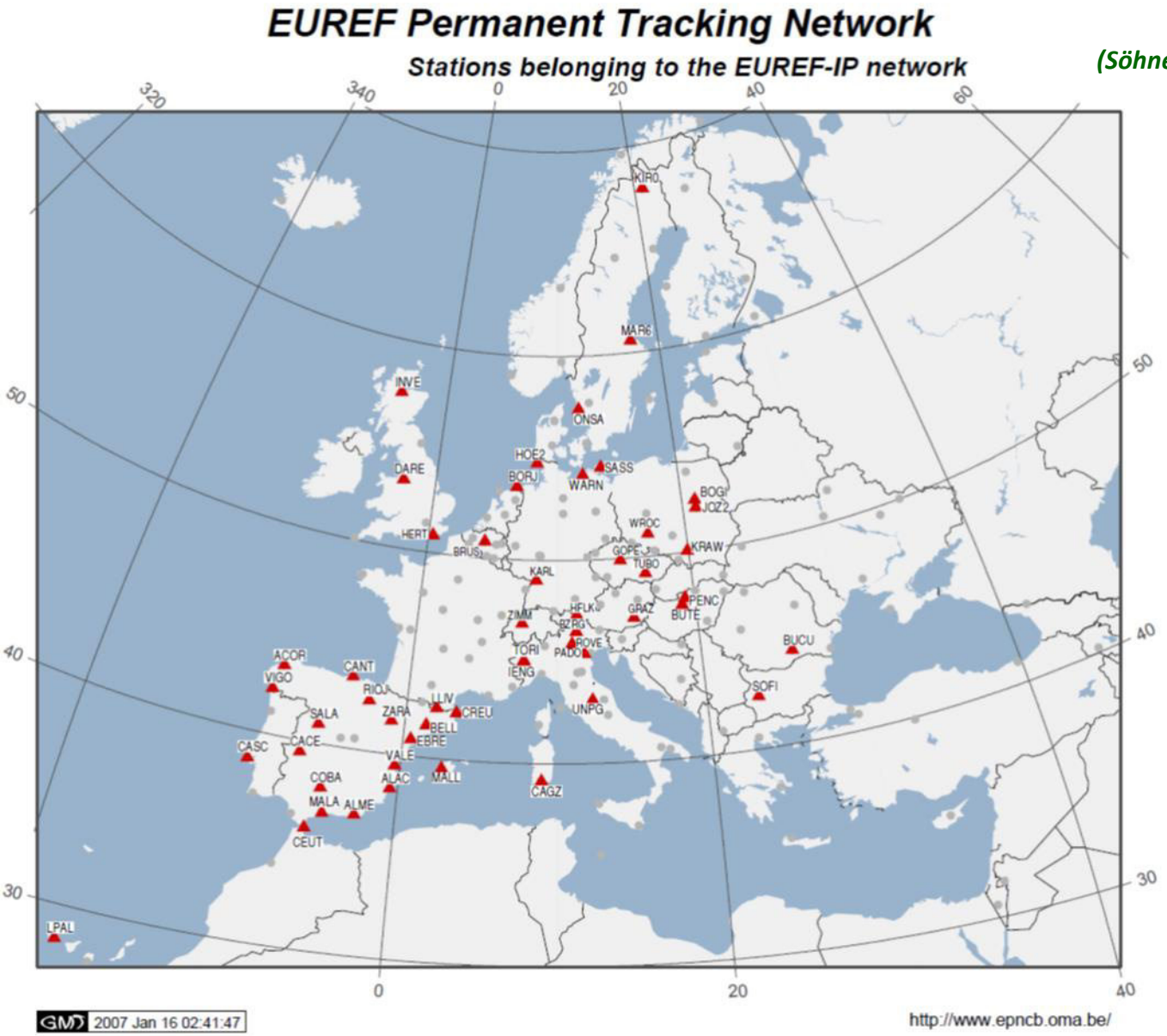


CASCAIS NA EPN



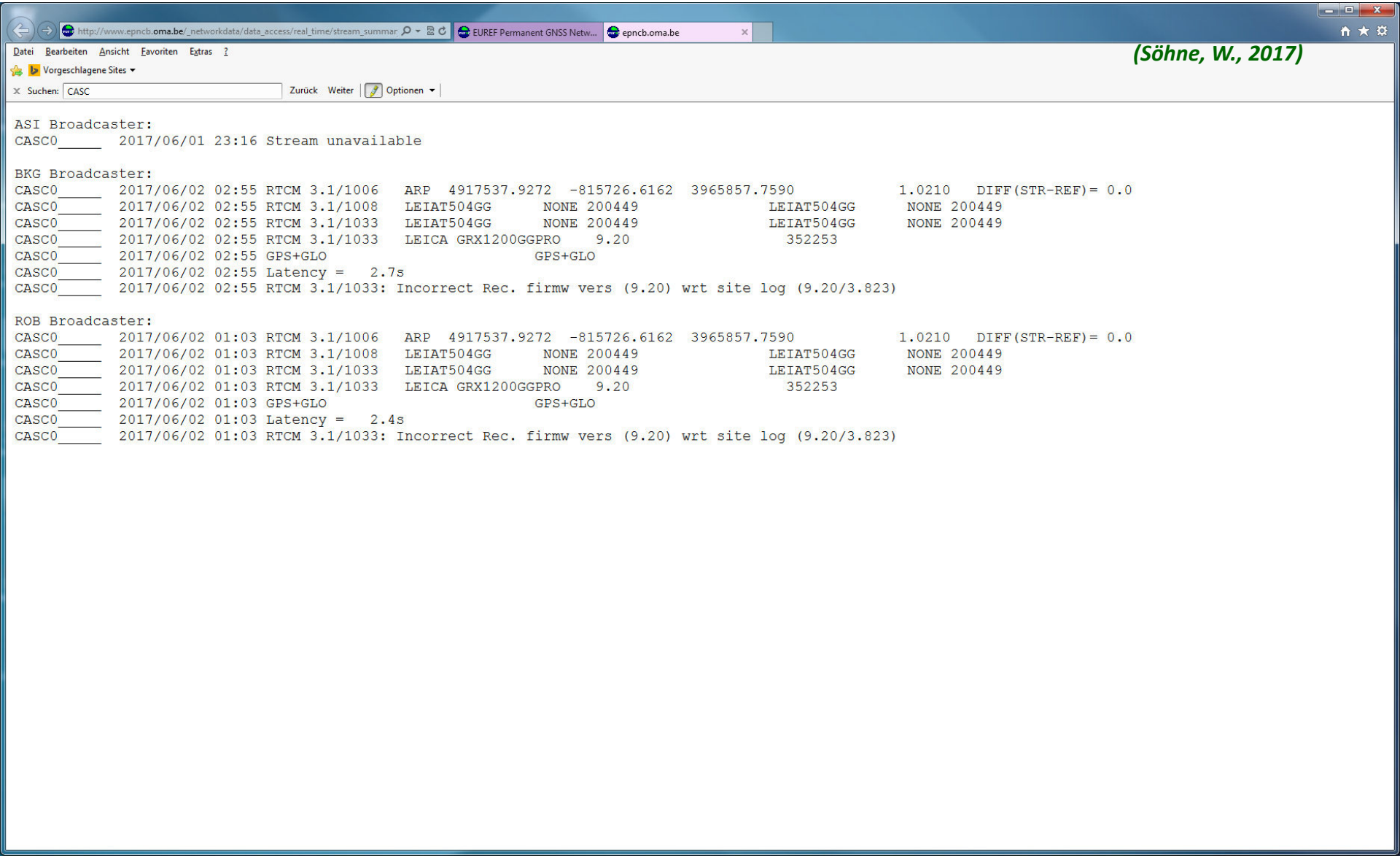
(Bruyninx, C., 2017)

CASCAIS "REAL TIME - Ntrip"



(Söhne, W., 2017)

CASCAIS "REAL TIME - Ntrip"



(Söhne, W., 2017)

```
ASI Broadcaster:
CASC0_____  2017/06/01 23:16 Stream unavailable

BKG Broadcaster:
CASC0_____  2017/06/02 02:55 RTCM 3.1/1006   ARP  4917537.9272  -815726.6162  3965857.7590           1.0210   DIFF(STR-REF)= 0.0
CASC0_____  2017/06/02 02:55 RTCM 3.1/1008   LEIAT504GG      NONE 200449              LEIAT504GG      NONE 200449
CASC0_____  2017/06/02 02:55 RTCM 3.1/1033   LEIAT504GG      NONE 200449              LEIAT504GG      NONE 200449
CASC0_____  2017/06/02 02:55 RTCM 3.1/1033   LEICA GRX1200GGPRO    9.20                 352253
CASC0_____  2017/06/02 02:55 GPS+GLO                        GPS+GLO
CASC0_____  2017/06/02 02:55 Latency =   2.7s
CASC0_____  2017/06/02 02:55 RTCM 3.1/1033: Incorrect Rec. firmw vers (9.20) wrt site log (9.20/3.823)

ROB Broadcaster:
CASC0_____  2017/06/02 01:03 RTCM 3.1/1006   ARP  4917537.9272  -815726.6162  3965857.7590           1.0210   DIFF(STR-REF)= 0.0
CASC0_____  2017/06/02 01:03 RTCM 3.1/1008   LEIAT504GG      NONE 200449              LEIAT504GG      NONE 200449
CASC0_____  2017/06/02 01:03 RTCM 3.1/1033   LEIAT504GG      NONE 200449              LEIAT504GG      NONE 200449
CASC0_____  2017/06/02 01:03 RTCM 3.1/1033   LEICA GRX1200GGPRO    9.20                 352253
CASC0_____  2017/06/02 01:03 GPS+GLO                        GPS+GLO
CASC0_____  2017/06/02 01:03 Latency =   2.4s
CASC0_____  2017/06/02 01:03 RTCM 3.1/1033: Incorrect Rec. firmw vers (9.20) wrt site log (9.20/3.823)
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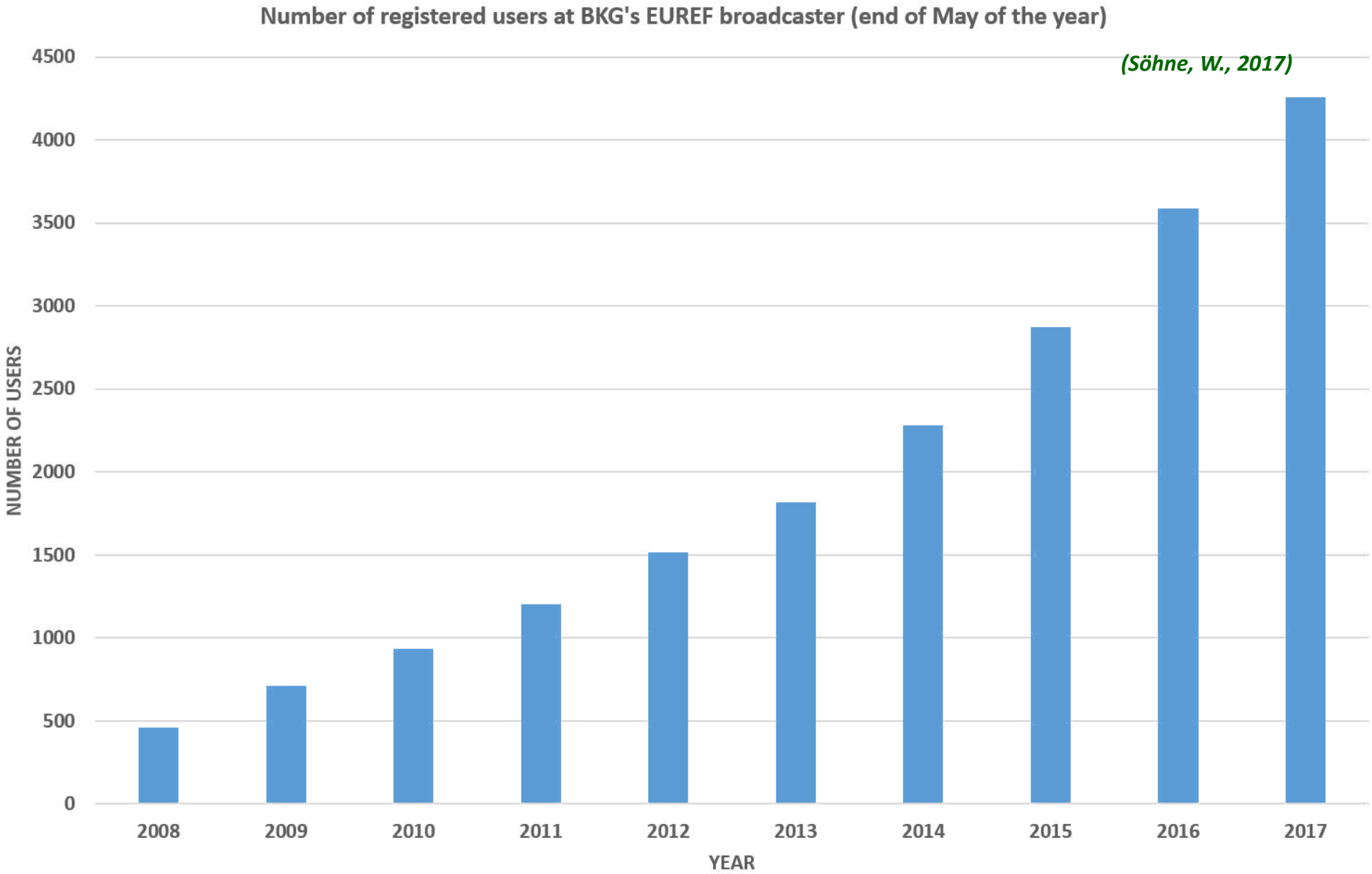
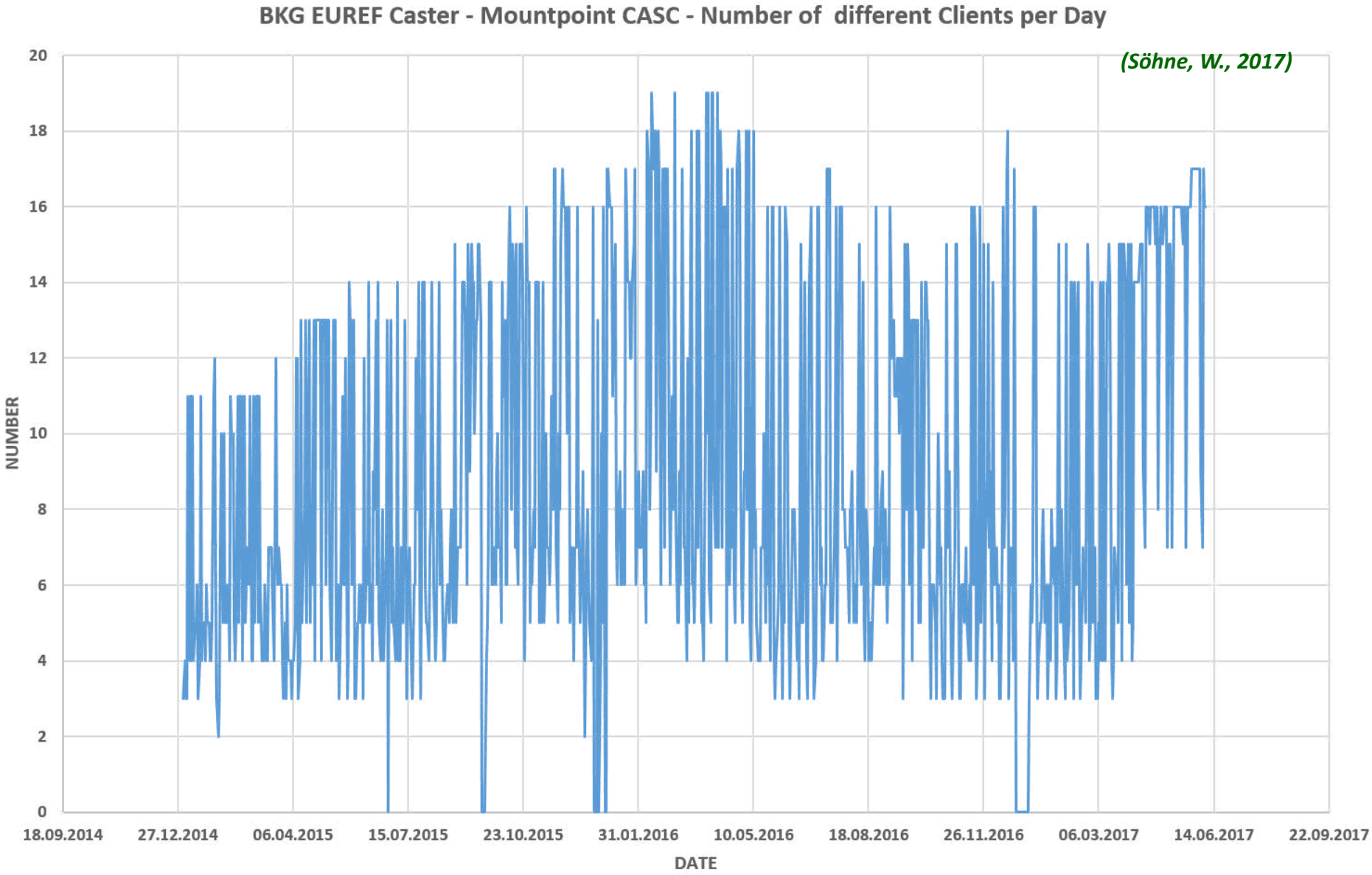
CASCAIS "REAL TIME - Ntrip"

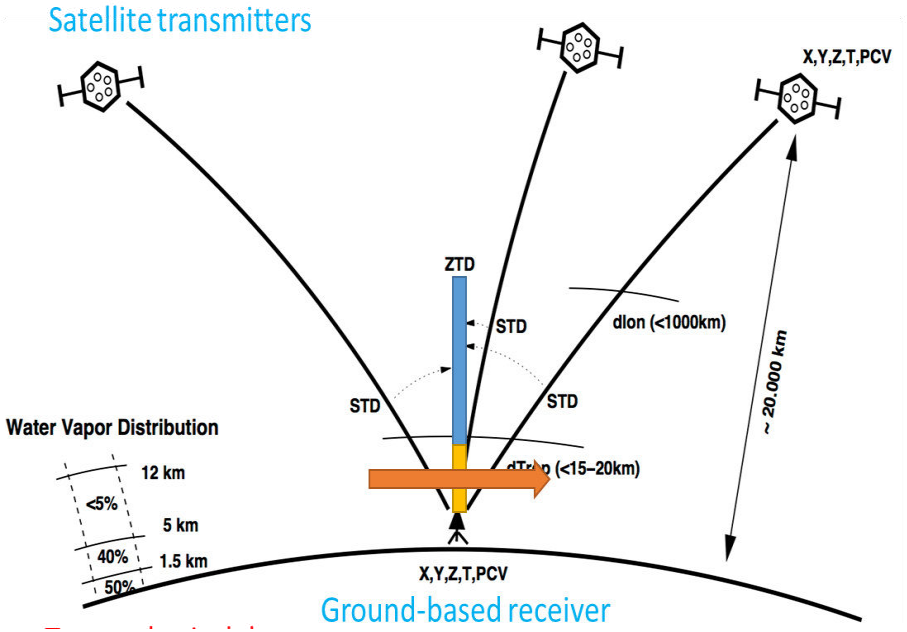


CASCAIS "REAL TIME - Ntrip"



O CONCEITO

(Pacione, R., 2017)



$$L_S = 10^{-6} \int N(s)ds$$

$$N = k_1 \cdot \left(\frac{P}{T}\right) + k_2 \cdot \left(\frac{e}{T}\right) + k_3 \cdot \left(\frac{e}{T^2}\right)$$

(Smith & Weintraub 1953)

P = surface atmospheric pressure [hPa]

e = water vapour pressure [hPa]

T = temperature [K]

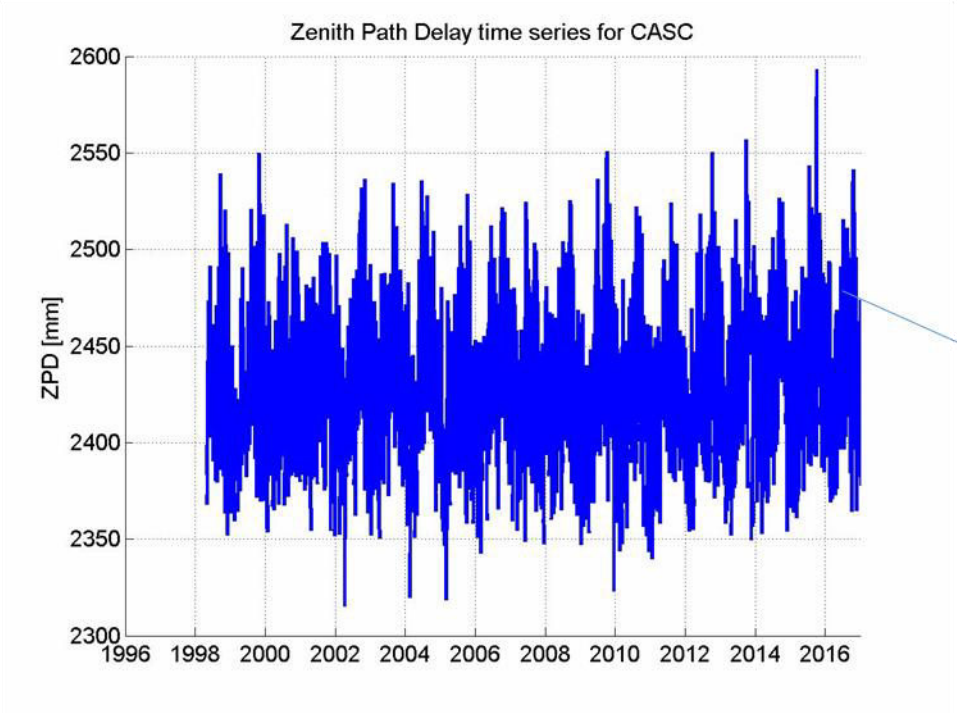
k_1, k_2, k_3 empirically determined coefficients

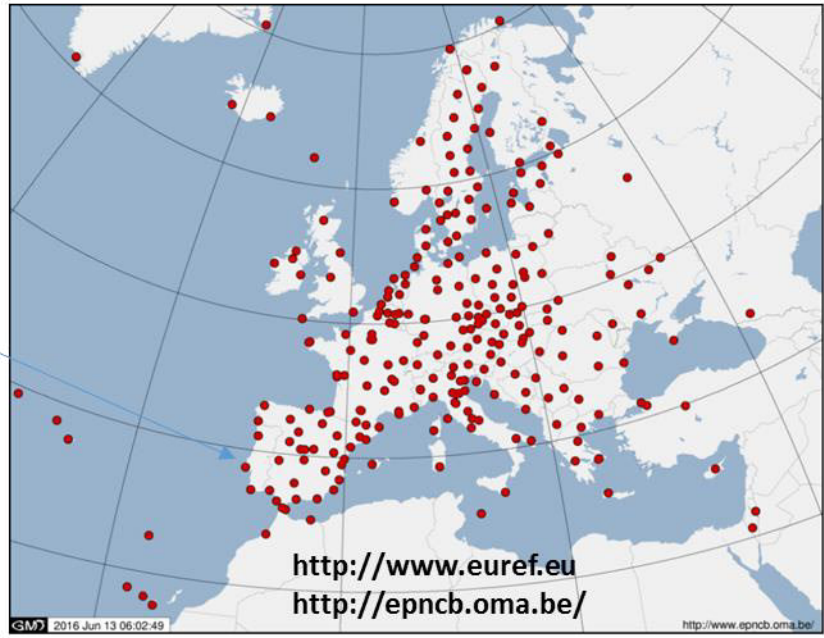
CASCAIS NO PROCESSAMENTO DE ROTINA

(Pacione, R., 2017)

Beside site coordinates, ZTD and horizontal gradients are routinely estimated by the EPN ACs and they are the input to generate each week the combined EPN troposphere solution containing the combined troposphere estimates with an hourly sampling rate.

http://www.epncb.oma.be/_productsservices/troposphere/zpd_timeseries_station.php?station=CASC00PRT

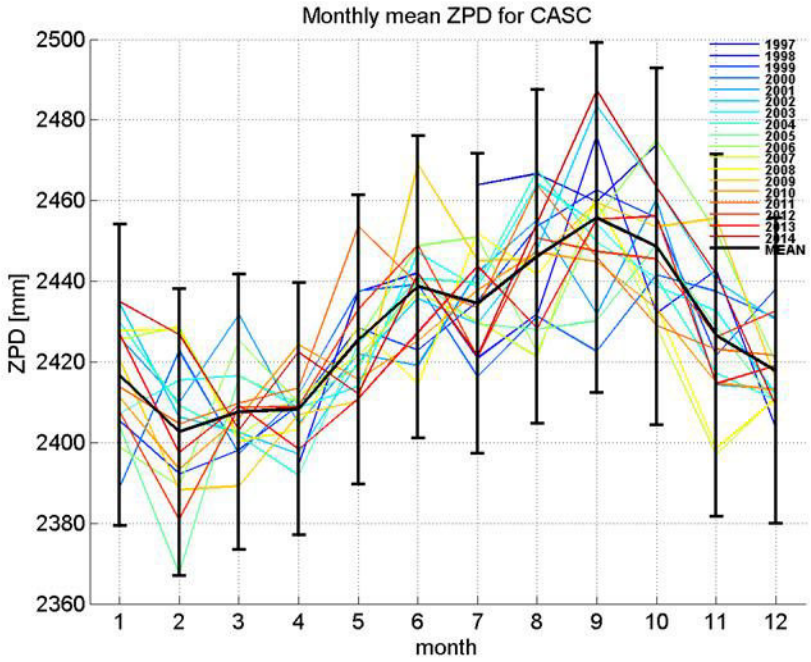


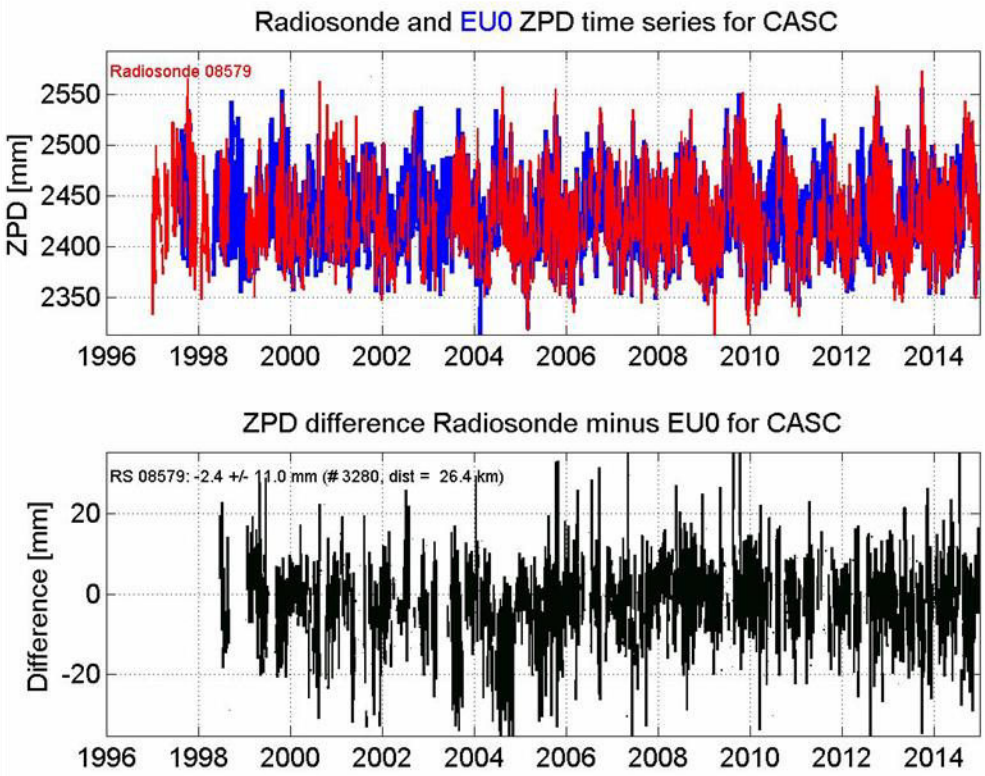


CASCAIS NO REPROCESSAMENTO

(Pacione, R., 2017)

CASC data have been homogeneously reprocessed in the framework of the 2nd EPN Reprocessing campaign thus providing a reference solution suitable for climate research



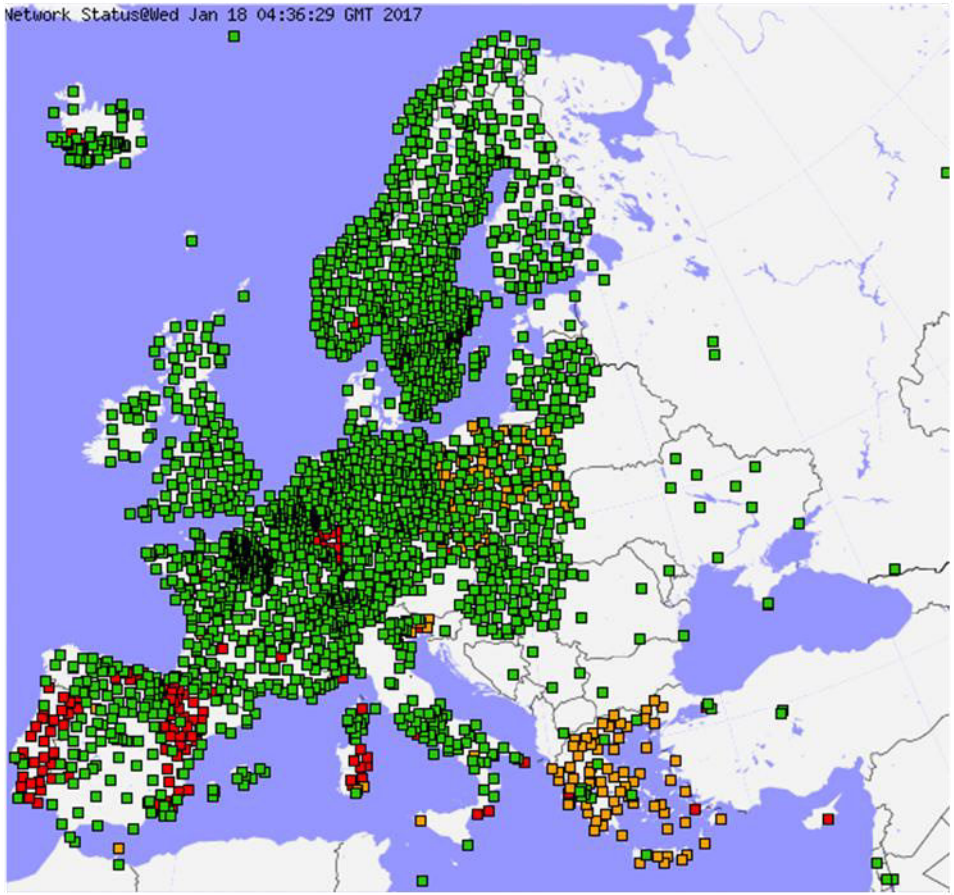


Pacione, R., Araszkiewicz, A., Brockmann, E., and Dousa, J.: EPN Repro2: A reference GNSS tropospheric dataset over Europe, Atmos. Meas. Tech., 10, 1689–1705, doi: 10.5194/amt-2016-369, 2017.

E-GVAP: METEOROLOGIA GNSS

(Pacione, R., 2017)

EUMETNET
The Network of European Meteorological Services



E-GVAP – http://egvap.dmi.dk/

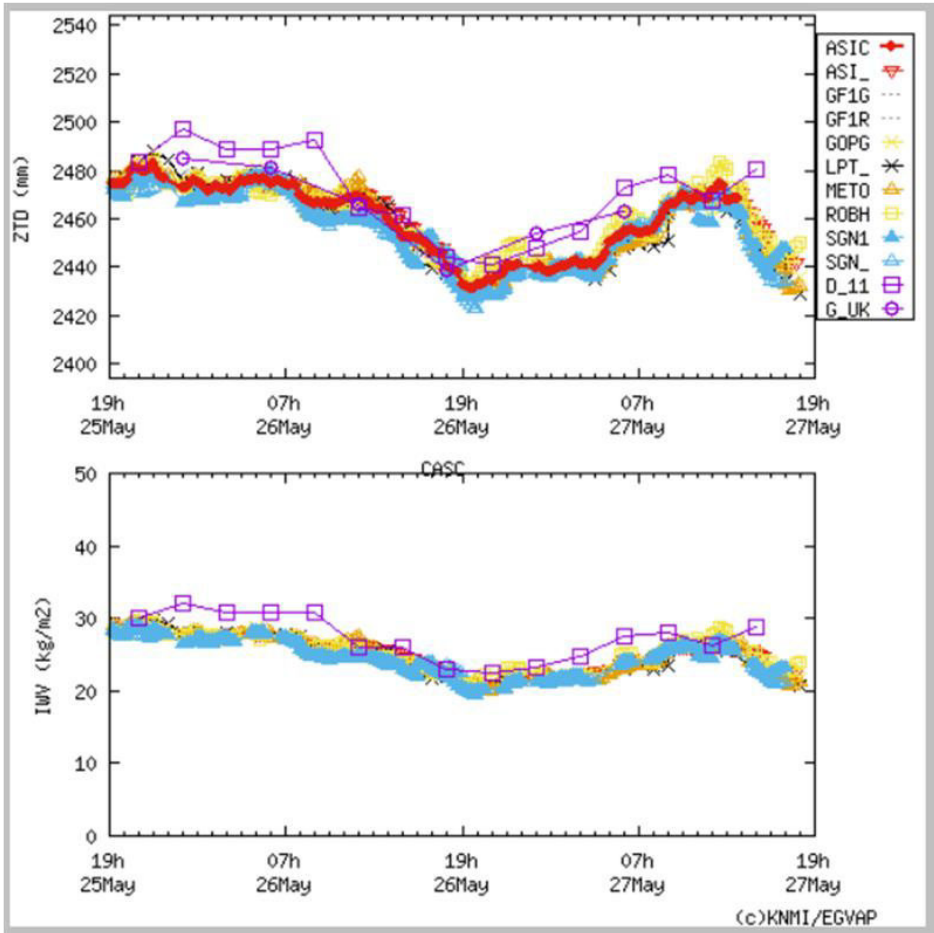
The EIG EUMETNET GNSS Water Vapour Programme, Phases I-III (2004-2017)

- EIG EUMETNET Project coordinating the **near real-time** delivery of data from ~3000 GPS sites delivering > **14M ZTDs pcm.**
- Focus is on GPS-only **hourly processing**, delivering only ZTD **in 90mins.**
- **Operational assimilation** at a few European National Met Services **since 2006,** many others under testing.
- Use of E-GVAP ZTDs has proven **positive impact** on NWP forecast skill.
- Surface T and P used for conversion to Integrated Water Vapour **(IWV).**
- Active Quality Control **(AQC)** in place.
- **MoUs** in place with **EUREF** and **EUPOS.**

CASCAIS NO E-GVAP

(Pacione, R., 2017)

CASC data are analyzed on hourly bases by several E-GVAP ACs in the E-GVAP framework to be used in operational meteorology



HIRLAM(KNMI) AN - GPS ZTD

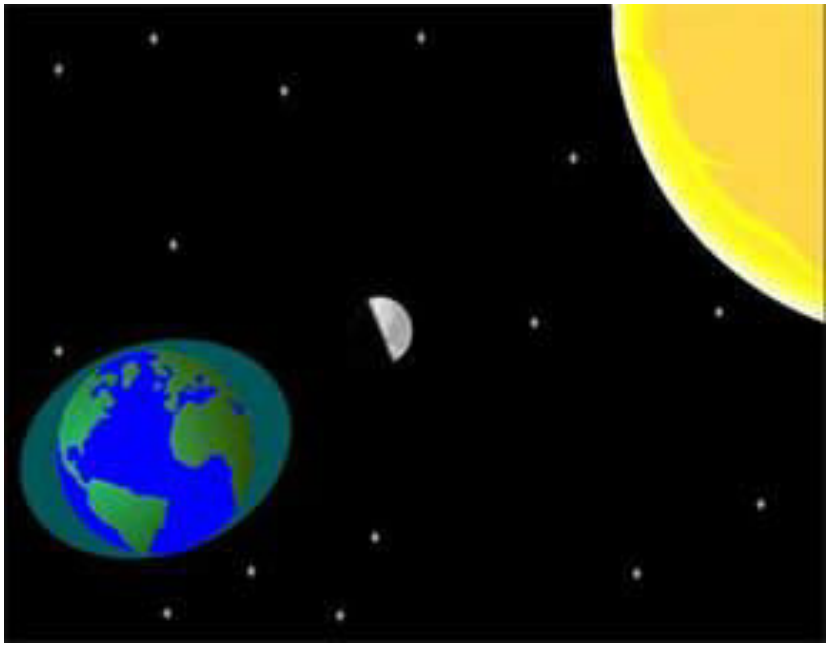
7day stat. 2017/03/09 - 2017/03/17

AC	num	bias	RMS	stddev
ASIC	55	-1.6	8.2	8.1
ASI	53	3.3	14.2	13.8
GOPG	56	-2.3	8.3	8.0
GUK	52	-2.2	10.4	10.1
LPT	55	0.0	0.0	0.0
ROBH	55	-3.1	9.8	9.3
SGN1	33	-8.6	22.2	20.5
SGN	33	-9.4	22.5	20.4

Notes

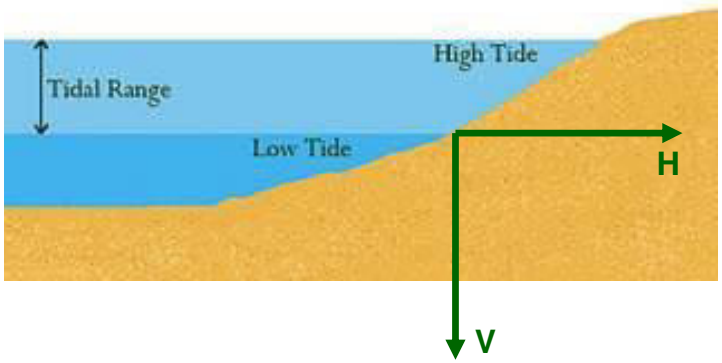
- Statistics are updated daily
- GPS ZTD are interpolated to NWP analysis time

MARÉS TERRESTRES

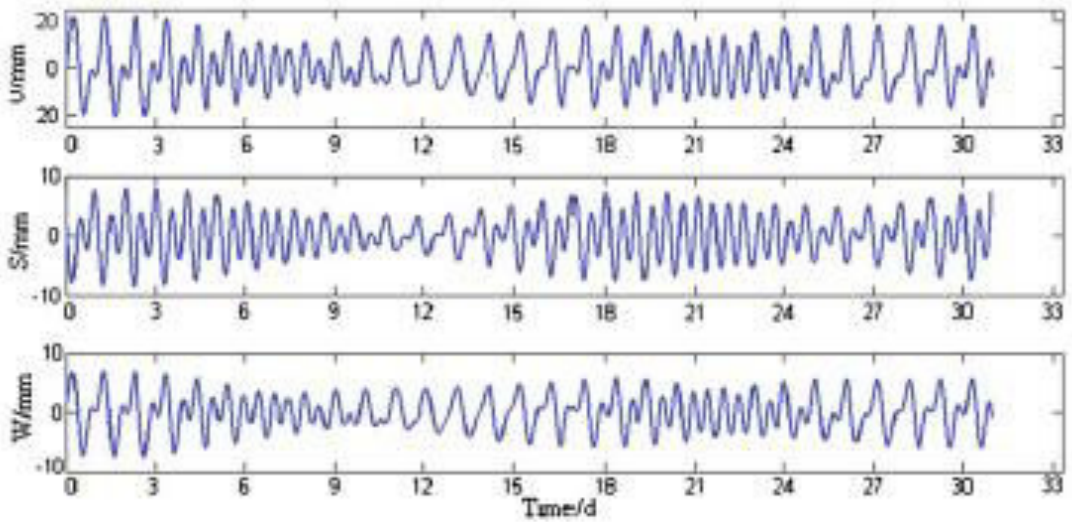


- IMPACTO NA TERRA SÓLIDA
- IMPACTO NA TERRA LÍQUIDA

CARREGAMENTO DA MARÉ OCEÂNICA (OTL)



COMPONENTES HORIZONTAL E VERTICAL DA FORÇA QUE ACTUA NA PARTE SÓLIDA RESULTANTE DA SUBIDA DA MARÉ

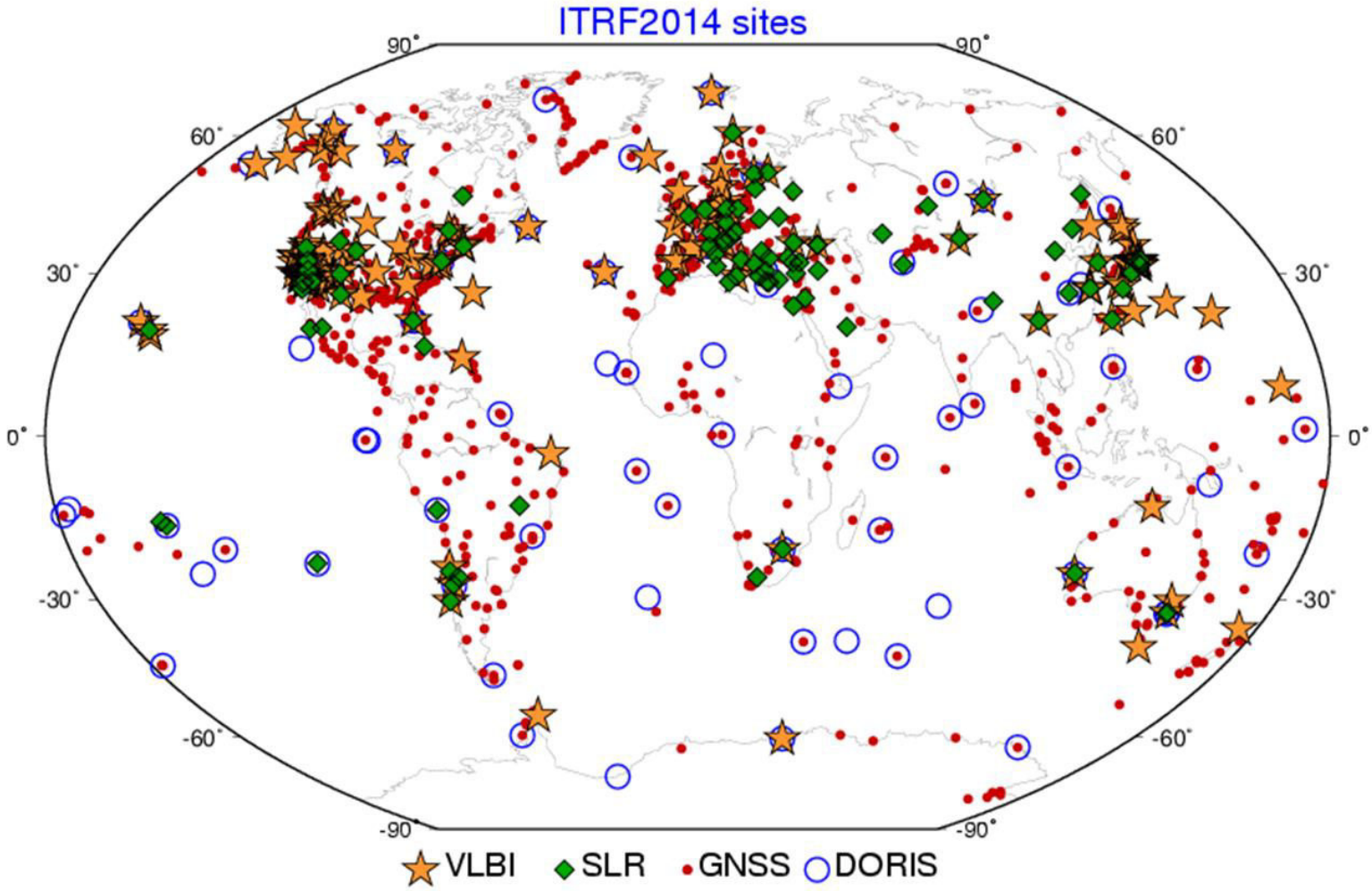


Deslocamentos observados na estação SHAO (China) em 2010/08

(Zhao, D. et al, 2013)

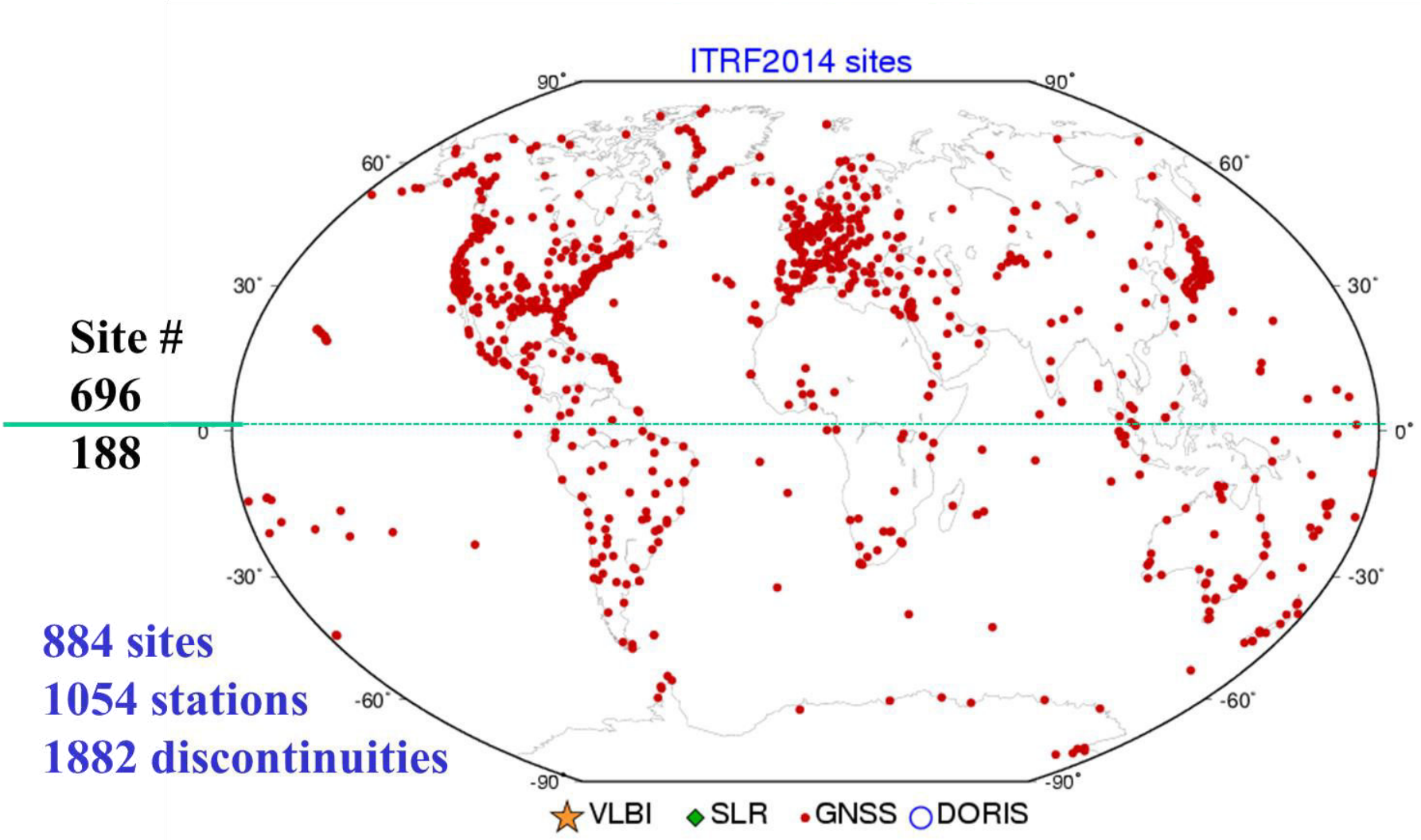
(Altamimi, Z., 2017)

ITRF2014 Network



(Altamimi, Z., 2017)

ITRF2014: GNSS

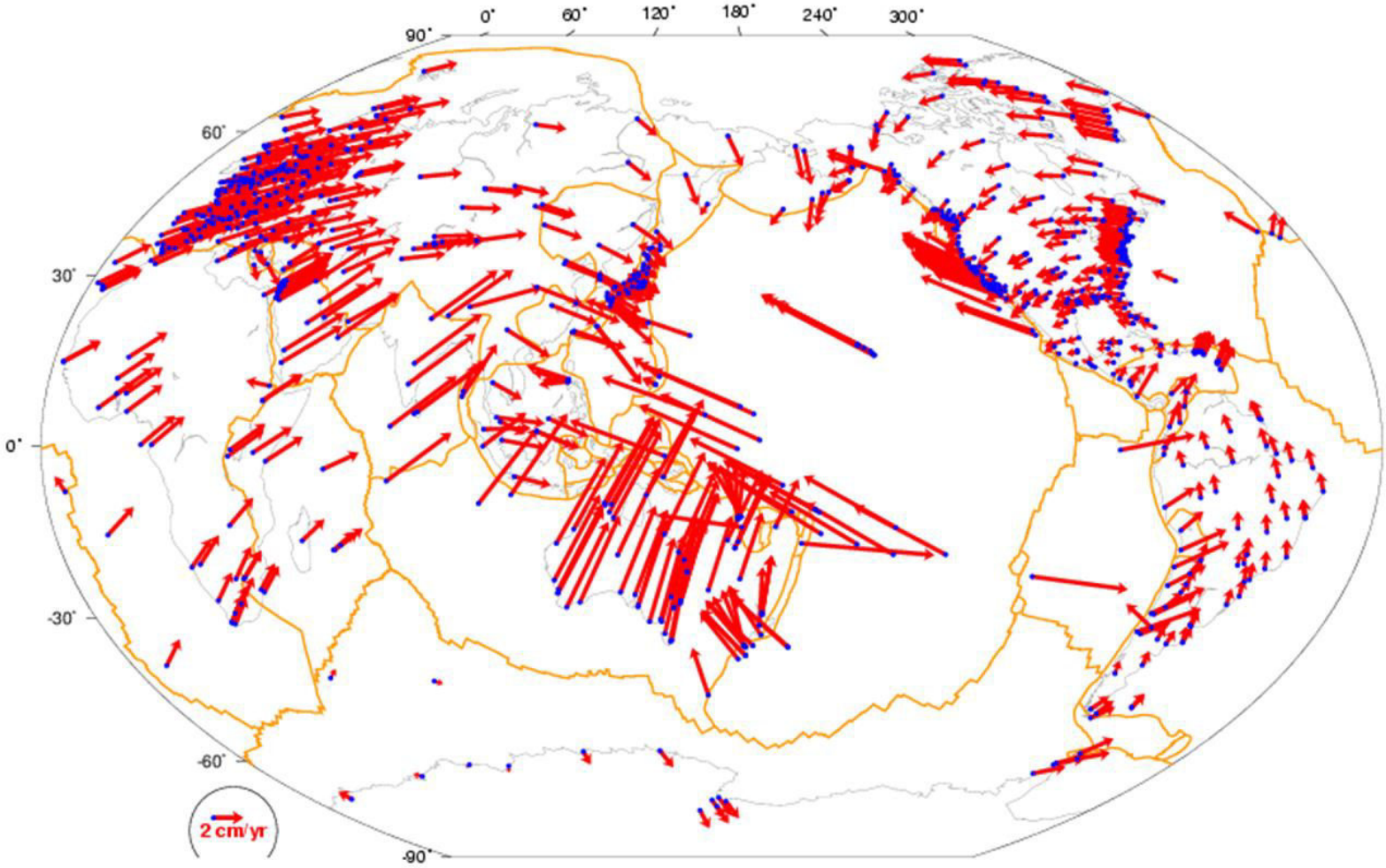


Site #
696
188

884 sites
1054 stations
1882 discontinuities

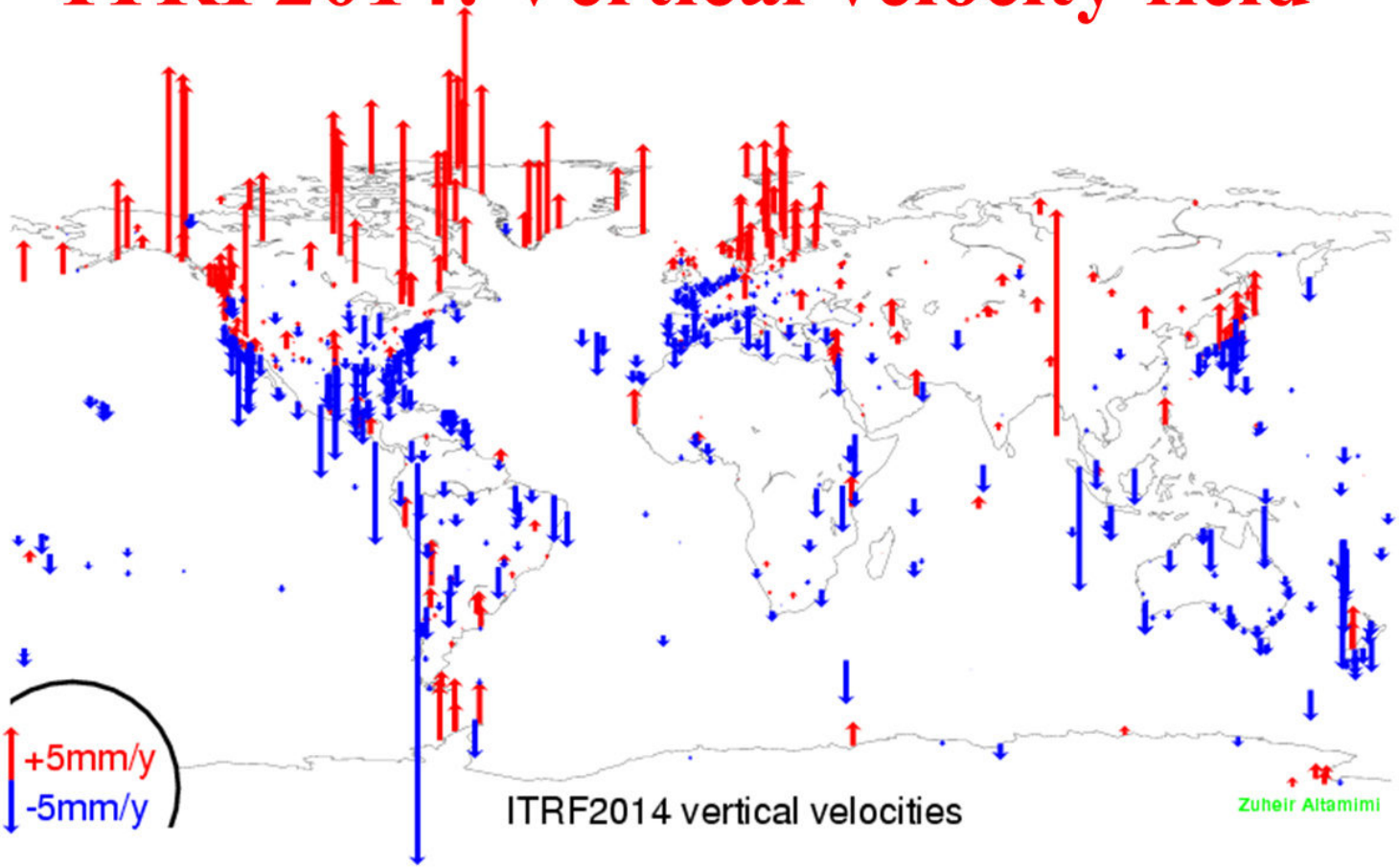
(Altamimi, Z., 2017)

ITRF2014: Horizontal velocity field



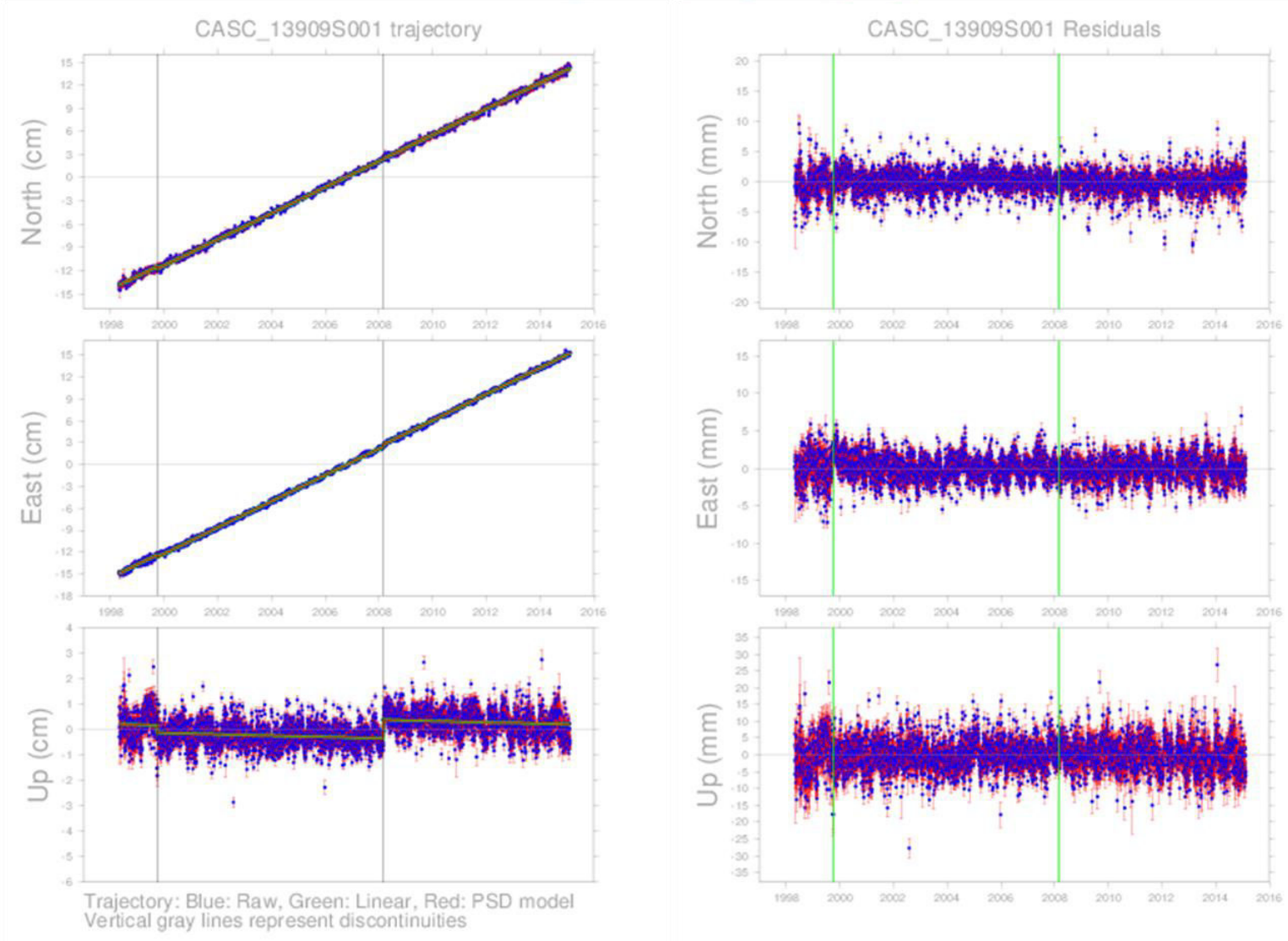
(Altamimi, Z., 2017)

ITRF2014: Vertical velocity field



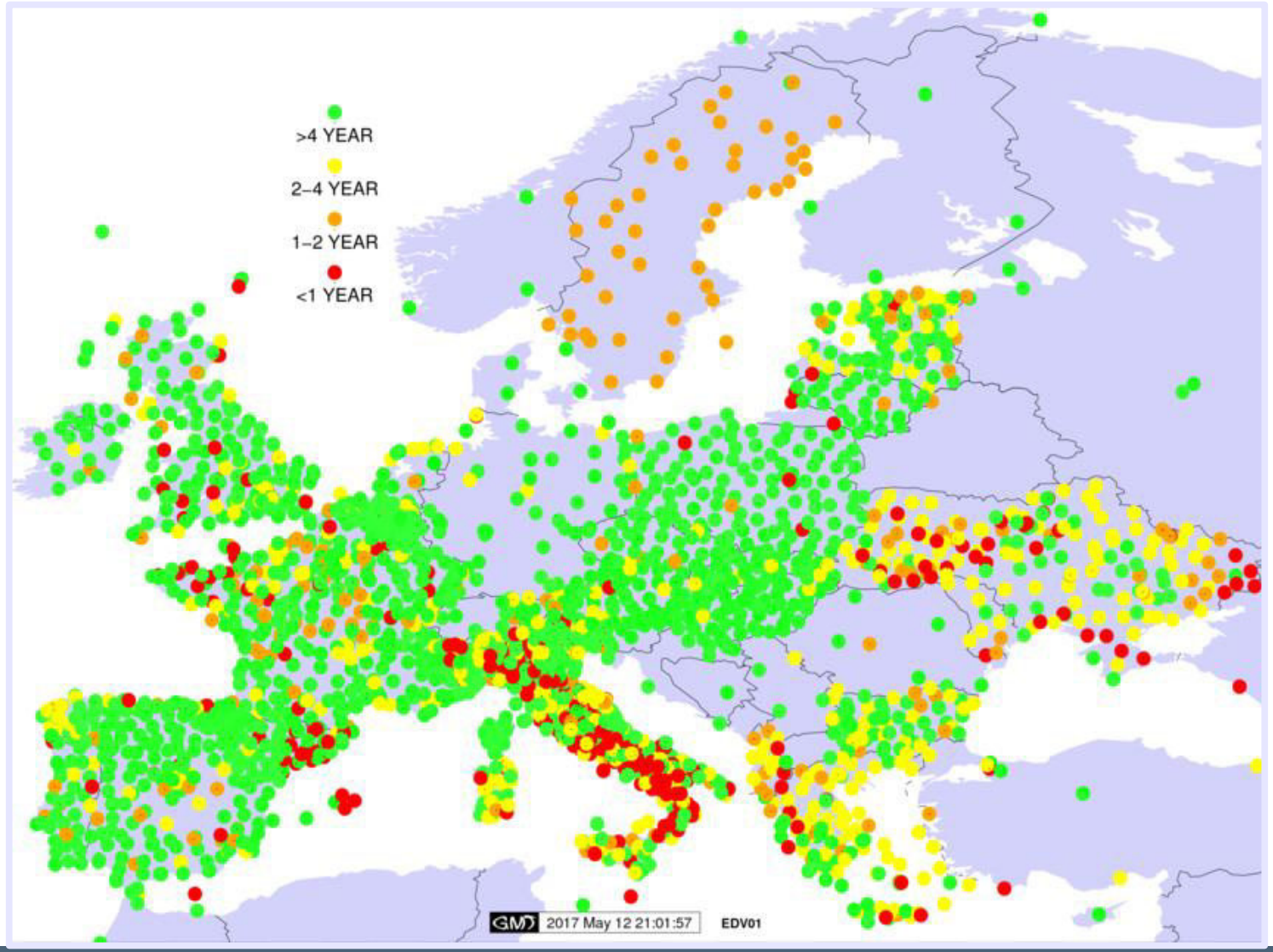
(Altamimi, Z., 2017)

ITRF2014: CASC



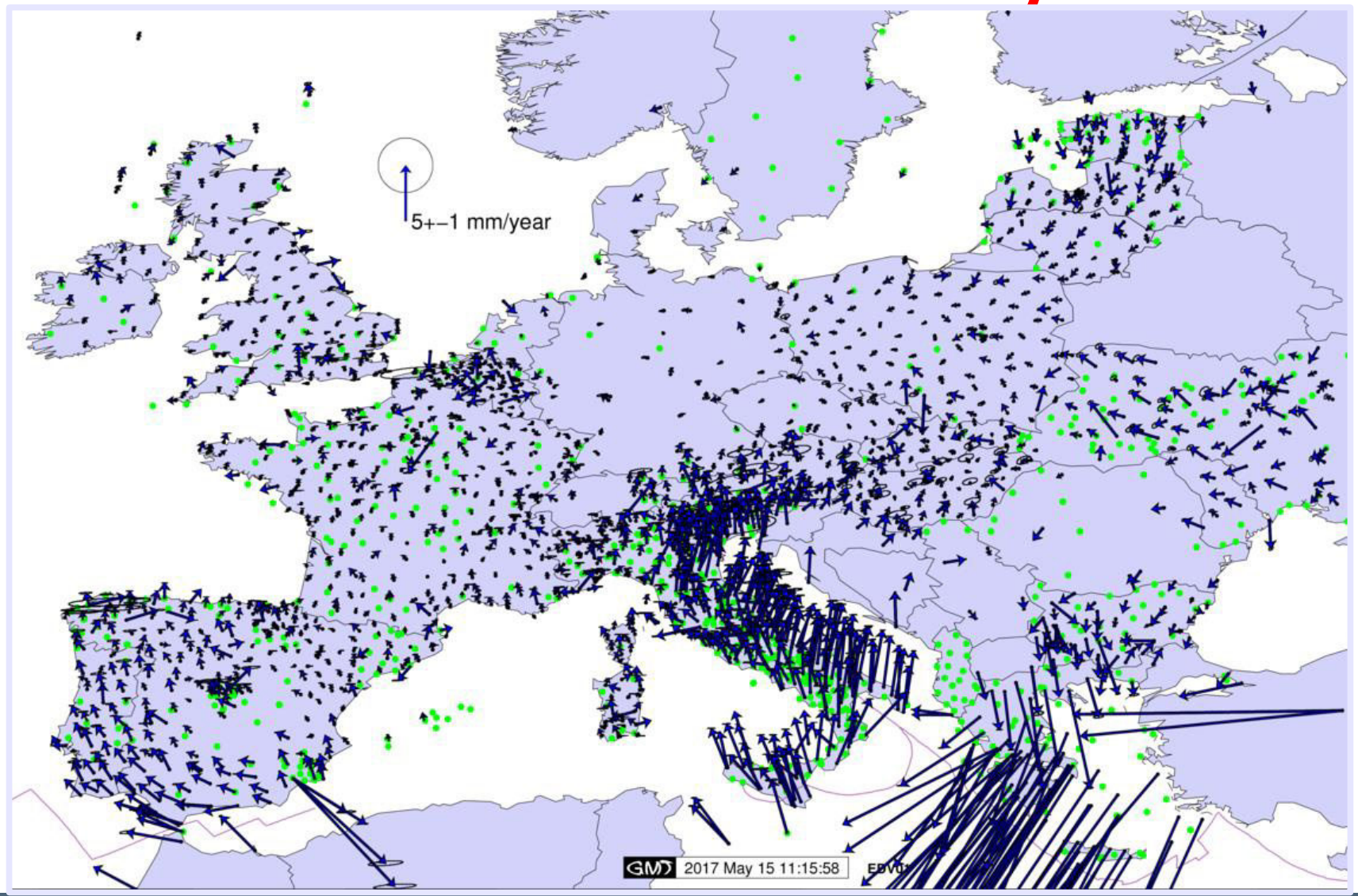
(Kenyeres, A., 2017)

EPN DENSIFICATION: SINEX AVAILABILITY



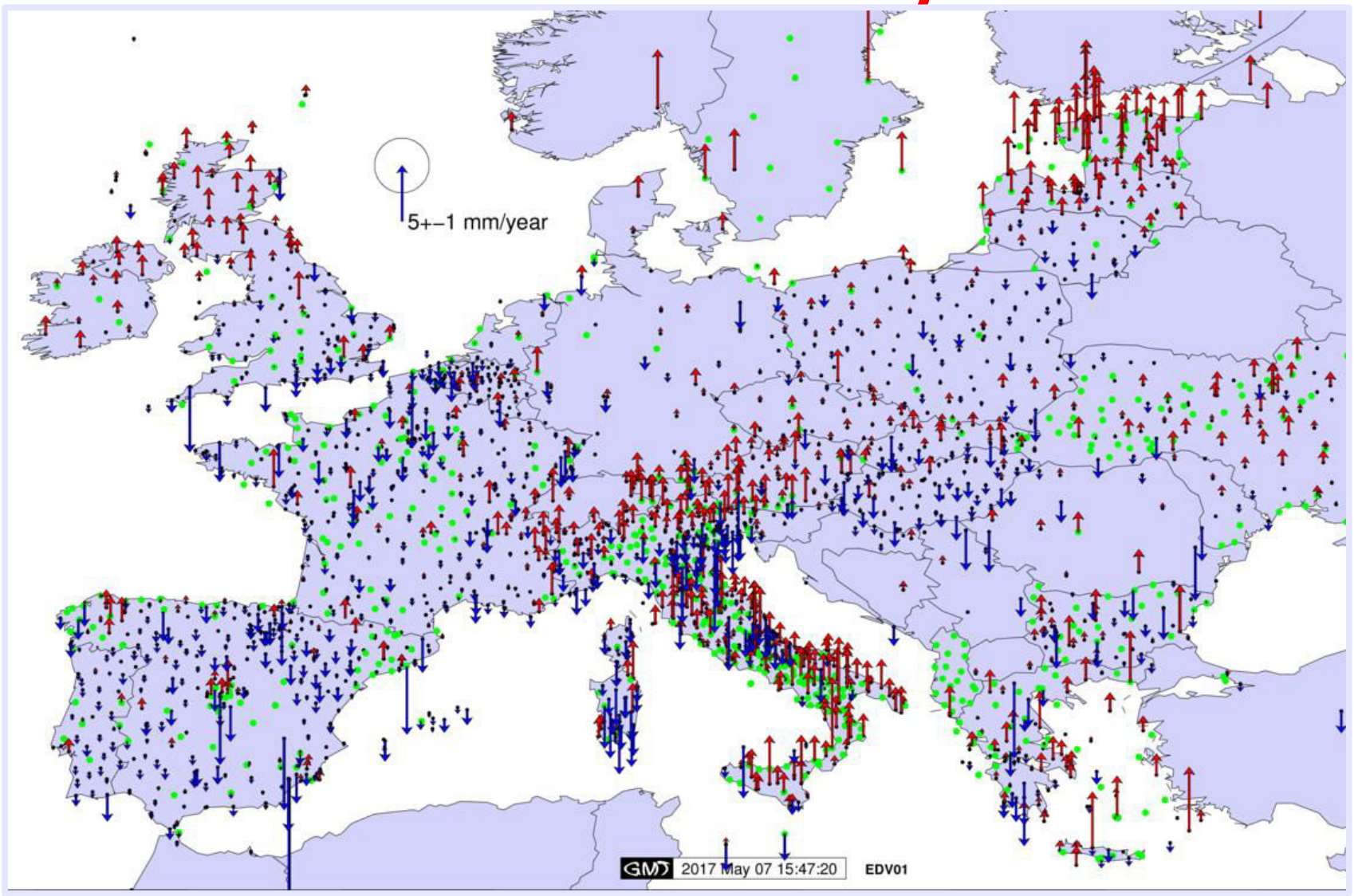
(Kenyeres, A., 2017)

ETRF2000 VELOCITIES L> 3 years



(Kenyeres, A., 2017)

UP VELOCITIES L> 3 years



CONSIDERAÇÕES FINAIS

- ***Impacto na grande massa de utilizadores***
  Crescente e com expectável melhoria de desempenho (novas constelações, etc.)
- ***Controlo de qualidade***
  Análise continua de desempenho e respectiva difusão aos utilizadores
- ***Arquivo e distribuição da informação***
  Capacidade de resposta às diferentes comunidades de utilizadores
- ***I&D***
  Identificação de fenómenos e validação de modelos em inúmeras áreas científicas
- ***Importância para o mundo global da informação geo-espacial***
  Iniciativa UN-GGIM (Global Geospatial Information Management)

RESOLUÇÃO DA ONU INTEGRADA NA UN-GGIM

General Assembly

Distr.: Limited
18 February 2015

Original: English

Sixty-ninth session
Agenda item 9
Report of the Economic and Social Council

Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Ethiopia, Fiji, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Jamaica, Japan, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Papua New Guinea, Philippines, Poland, Portugal, Republic of Korea, Samoa, Slovenia, Solomon Islands, Spain, Sweden, Tunisia, Tuvalu, United Kingdom and Great Britain and Northern Ireland, United States of America and Vanuatu: draft resolution

A global geodetic reference frame for sustainable development

RESOLUÇÃO DA ONU INTEGRADA NA UN-GGIM

Acknowledging that the global geodetic reference frame depends upon the participation of countries all around the globe, and the need to take action to strengthen international cooperation,

1. *Notes with appreciation* the establishment of a working group by the Committee of Experts on Global Geospatial Information Management to develop a global geodetic road map that addresses key elements relating to the development and sustainability of the global geodetic reference frame;

2. *Encourages* Member States and relevant international organizations to enhance global cooperation in providing technical assistance, especially for capacity development in geodesy for developing countries, with the aim of ensuring the development, sustainability and advancement of a global geodetic reference frame;

3. *Urges* Member States to implement open sharing of geodetic data, standards and conventions, on a voluntary basis, to contribute to the global reference frame and regional densifications through relevant national mechanisms and intergovernmental cooperation, and in coordination with the International Association of Geodesy;

4. *Also invites* Member States to commit to improving and maintaining appropriate national geodetic infrastructure as an essential means to enhance the global geodetic reference frame;

5. *Further invites* Member States to engage in multilateral cooperation that addresses infrastructure gaps and duplications towards the development of a more sustainable global geodetic reference frame;

6. *Invites* Member States to develop outreach programmes that make the global geodetic reference frame more visible and understandable to society.

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