European Velocity Field and EPN ETRS89 positions and velocities

Zuheir Altamimi, Juliette Legrand

Laboratoire de Recherche en Géodésie

Institut Géographique National, France

Dense European Velocity Field

- **Long term maintenance of the ETRS89**
- **Precise ETRS89 station positions & velocities of the EPN (Basis of the Velocity Model)**
- **Accurate frame definition using minimum constraints approach**

Datum Definition / Minimum Constraints (1/2)

X_R : **Reference TRF Solution** X_C : **Estimated TRF Solution**

$$X_R = X_C + A\theta$$

$$\theta = (T_1, T_2, T_3, D, R_1, R_2, R_3, \dot{T}_1, \dot{T}_2, \dot{T}_3, \dot{D}, \dot{R}_1, \dot{R}_2, \dot{R}_3)^T$$

L.S. gives

$$\theta = \overbrace{(A^T A)^{-1} A^T}^{\mathbf{B}} (X_R - X_C)$$

To have X_C expressed in the same frame as X_R (i.e. $\theta = 0$), we can write

$$B(X_R - X_C) = 0 \qquad (\Sigma_\theta)$$

In terms of NEQ

$$B^T \Sigma_\theta^{-1} B(X_R - X_C) = 0$$

Datum Definition / Minimum Constraints (2/2)

The initial NEQ system of space geodesy observations could be written as :

$$N_{unc}(\Delta X) = K \tag{3}$$

where $\Delta X = X - X_{apr}$ **(Linearized Unknowns)**

Selecting a Reference TRF (X_R), MC equation is :

$$B^T \Sigma_\theta^{-1} B(\Delta X) = B^T \Sigma_\theta^{-1} B(X_R - X_{apr}) \tag{4}$$

Cumulating (3) and (4) yields :

$$(N_{unc} + B^T \Sigma_\theta^{-1} B)(\Delta X) = K + B^T \Sigma_\theta^{-1} B(X_R - X_{apr})$$

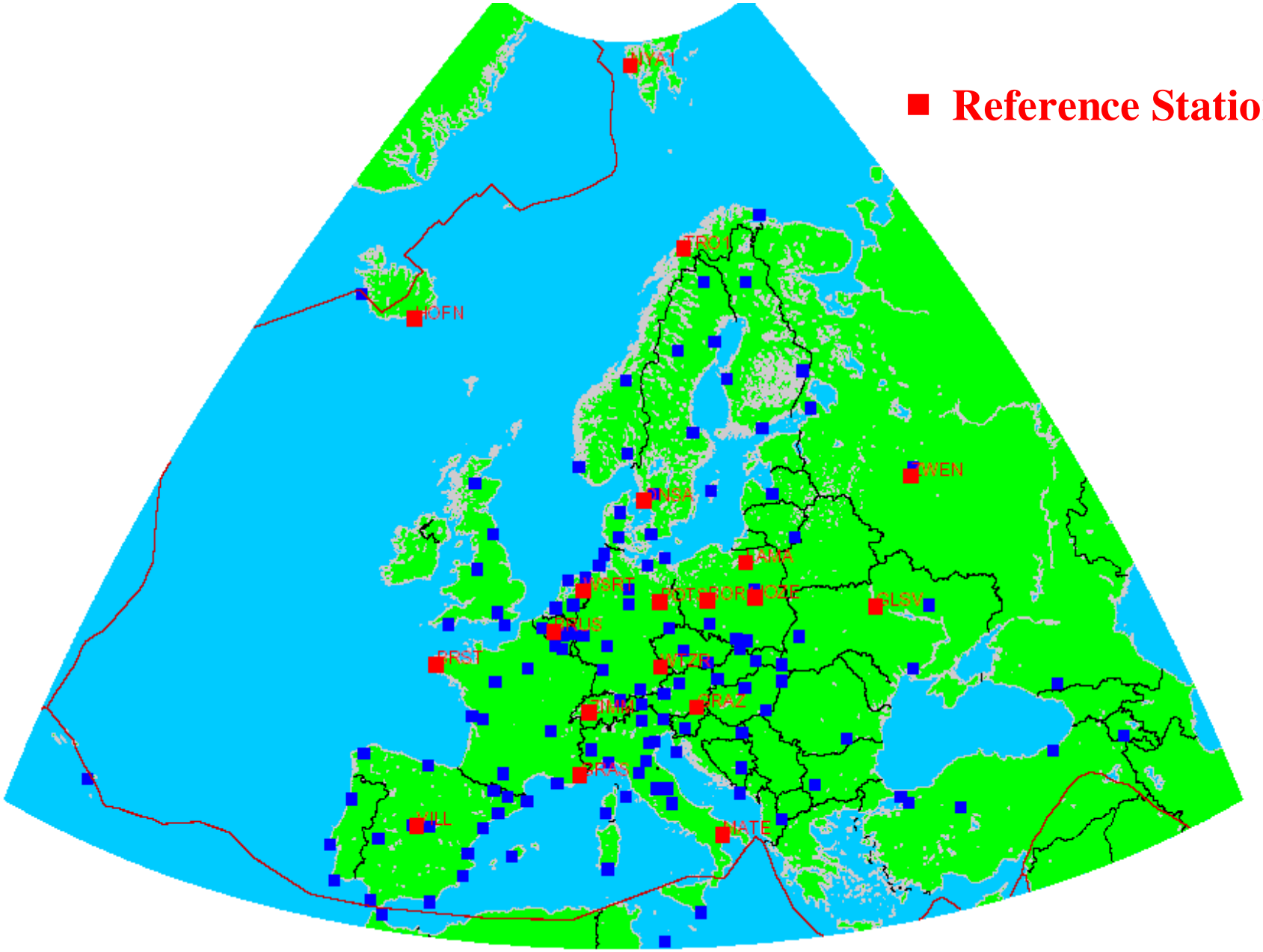
European Velocity Field
Start with EPN Wkly Combined Solutions

- **Remove Constraints**
- **Add Minimum constraints**
- **Reject outliers and properly handle discontinuities**

First results

Combination of weeks from 837 to 1263

EPN and Selected set of Reference Stations



TRF & EOP time series Combination

CATREF Software

INPUT: $X(t)$, **EOP(t) in daily/weekly/monthly SINEX files**

OUTPUT: $X(t_0)$, $\dot{X}$, **EOP(t),** $(\underbrace{T_x, T_y, T_z}_{\text{Geocenter}}, D, R_x, R_y, R_z)$

$$\begin{cases} X_s^i = X_{itrf}^i + (t_s^i - t_0)\dot{X}_{itrf}^i + T_k + D_k X_{itrf}^i + R_k X_{itrf}^i \\ \quad + (t_s^i - t_k)\left[\dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i\right] \\ \dot{X}_s^i = \dot{X}_{itrf}^i + \dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i \end{cases}$$

Datum Definition

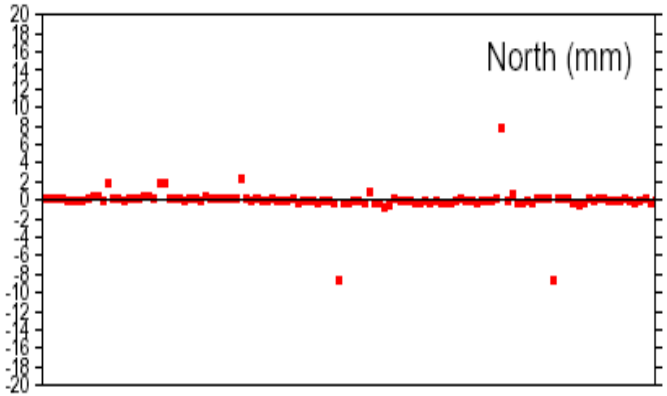
$$(A^T A)^{-1} A^T (X_{RS} - X_c) = 0$$

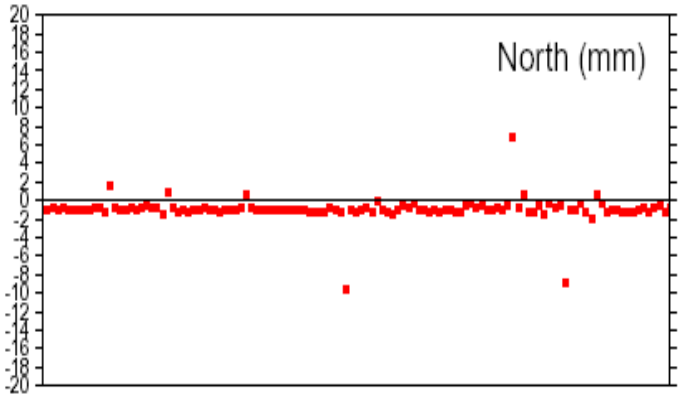
$$\begin{cases} x_s^p = x^p + R2_k \\ y_s^p = y^p + R1_k \\ UT_s = UT - \frac{1}{f} R3_k \\ \dot{x}_s^p = \dot{x}^p + \dot{R}2_k \\ \dot{y}_s^p = \dot{y}^p + \dot{R}1_k \\ LOD_s = LOD + \frac{\Lambda_0}{f}\dot{R}3_k \end{cases}$$

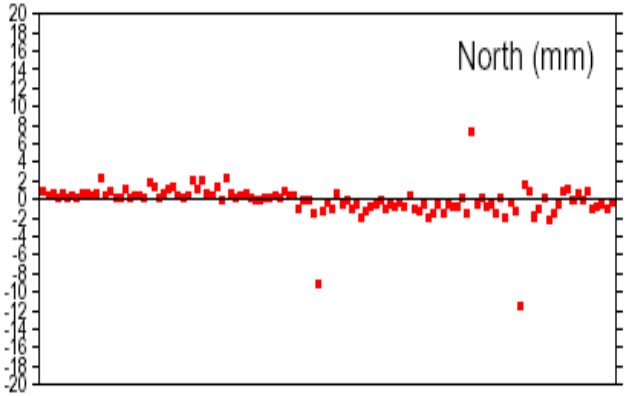
- **Matching common EOP parameters at UT noon**
- **Propagate at UT noon if rates are available**

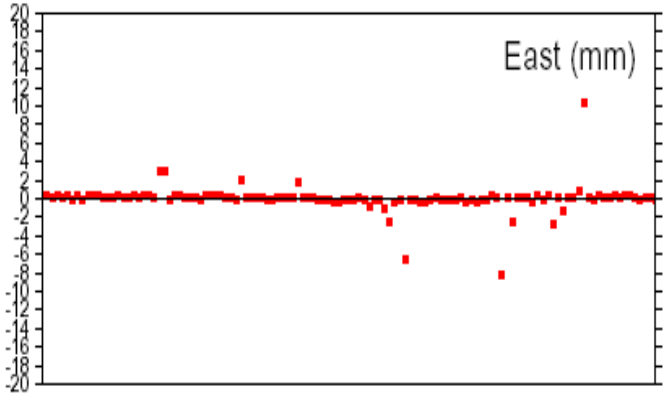
Differences btw Contsr'd and MC (W-1263)

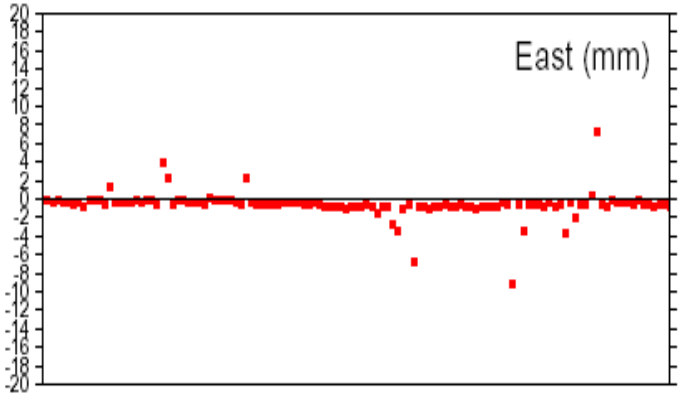
Using all stations as RS | **12 ITRF2000 Ref. Stations** | **16 ITRF2000 Ref. Stations**

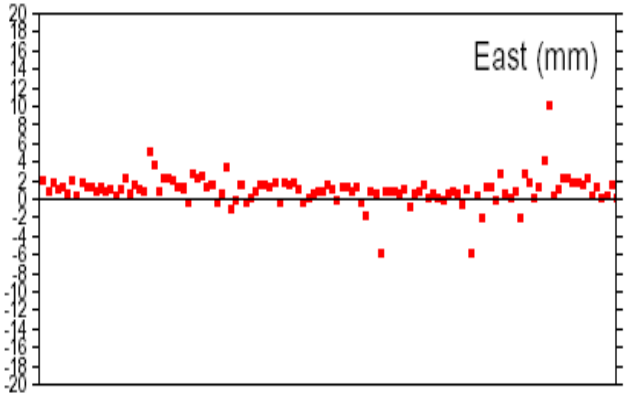


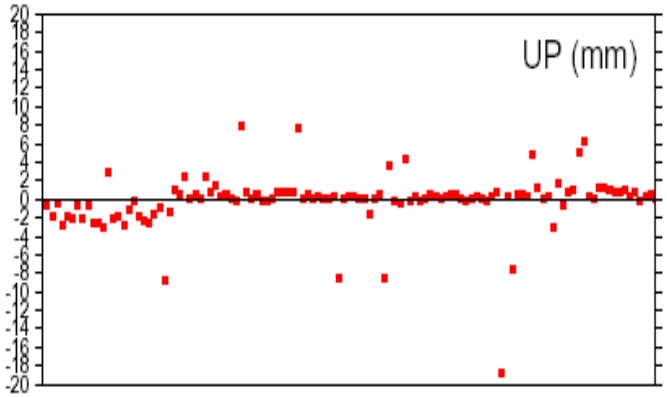


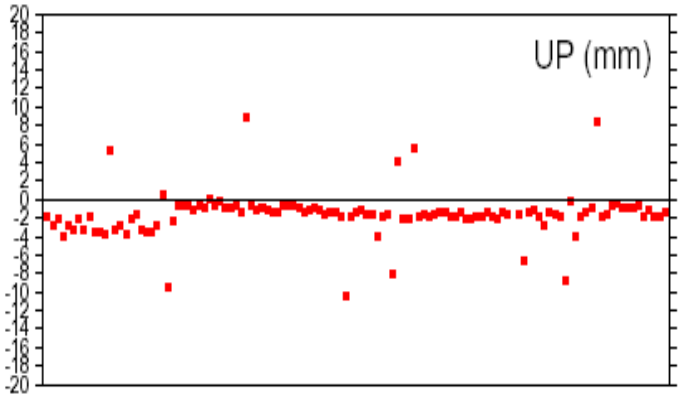


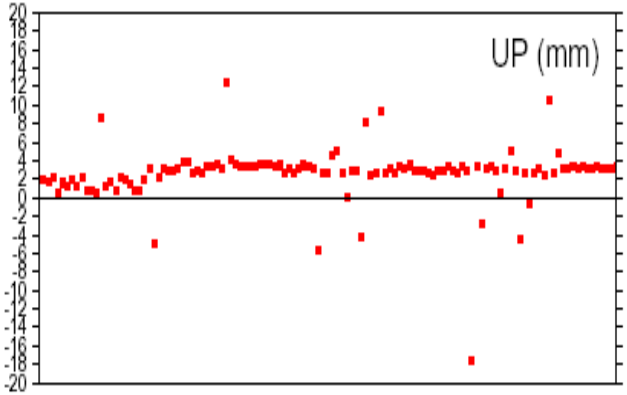






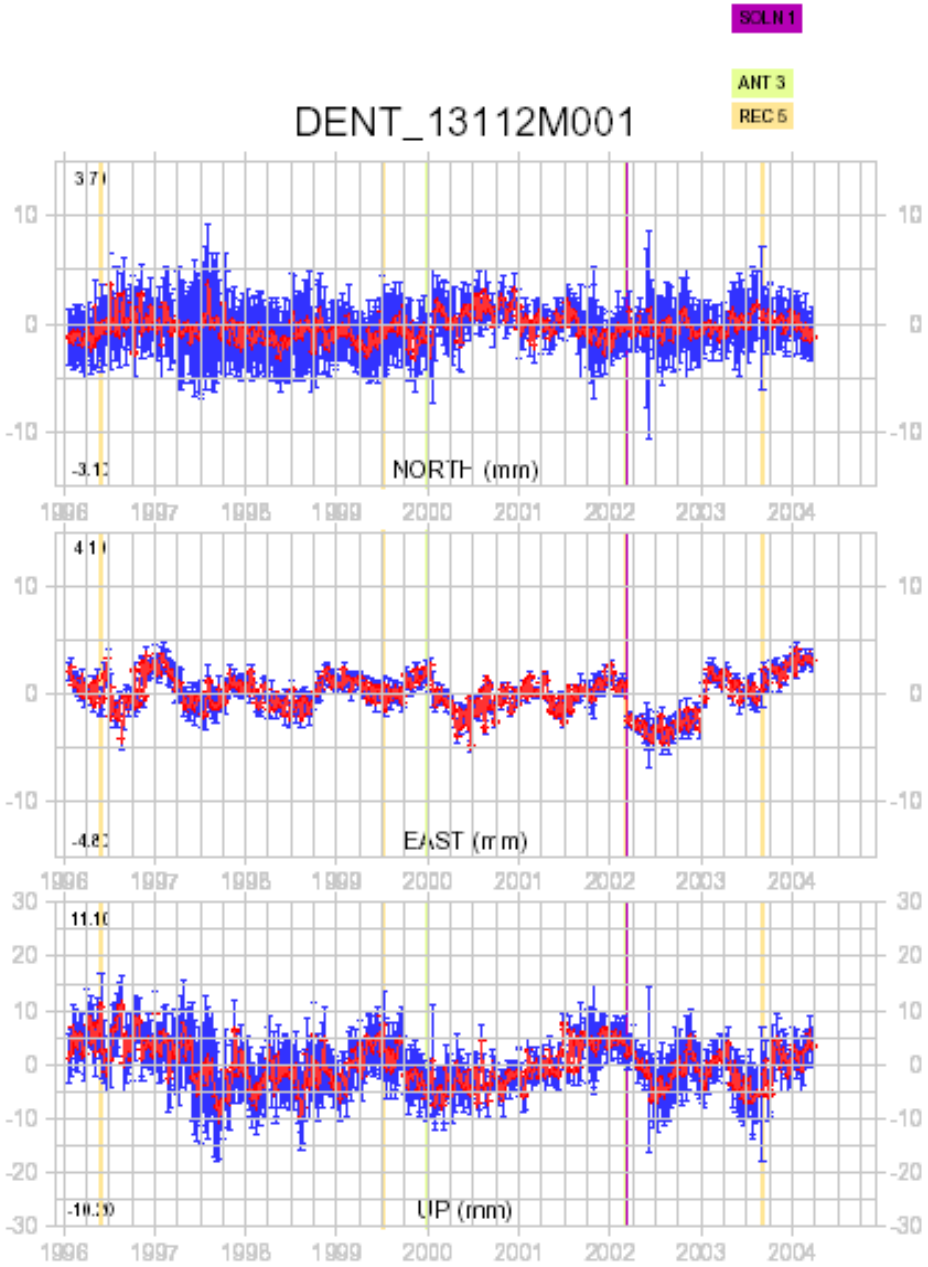


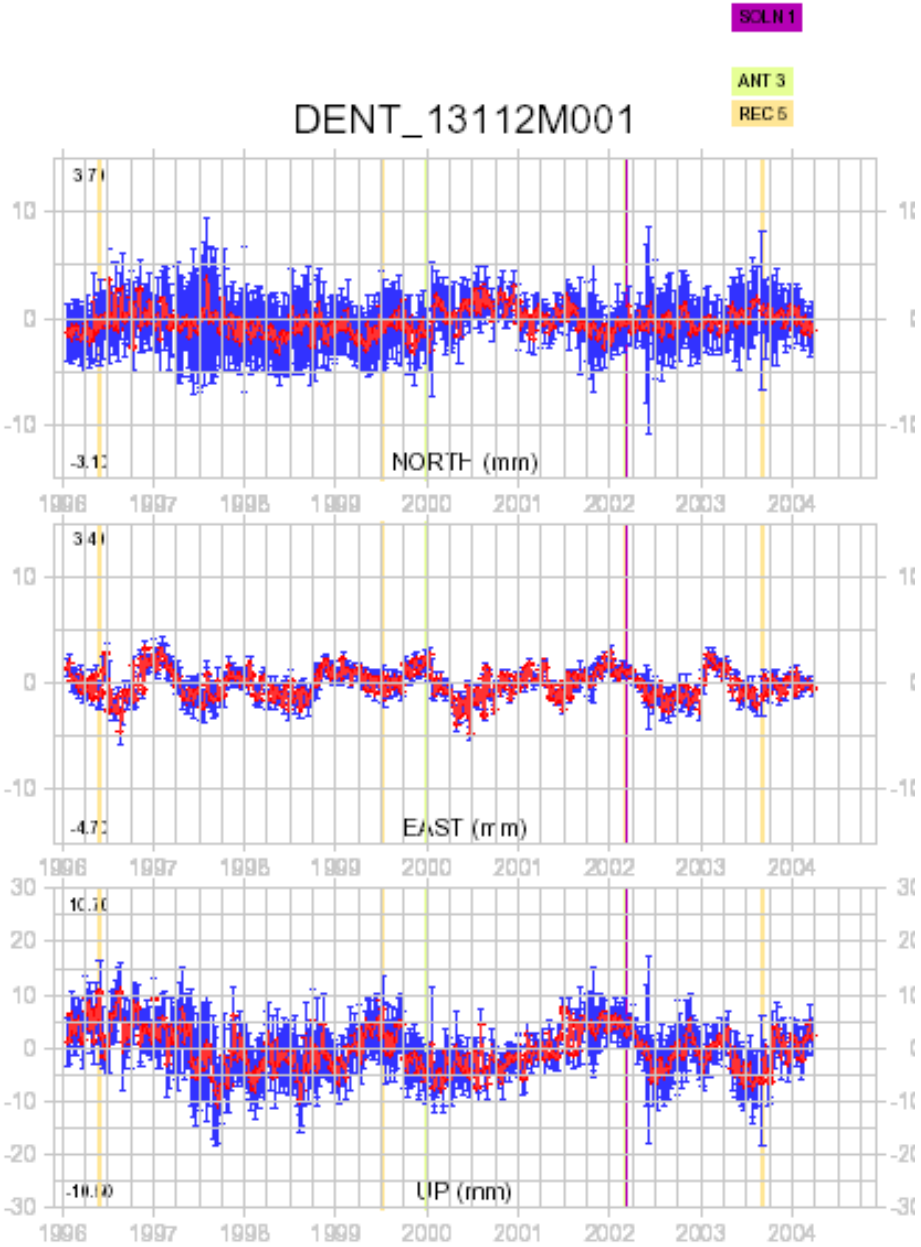




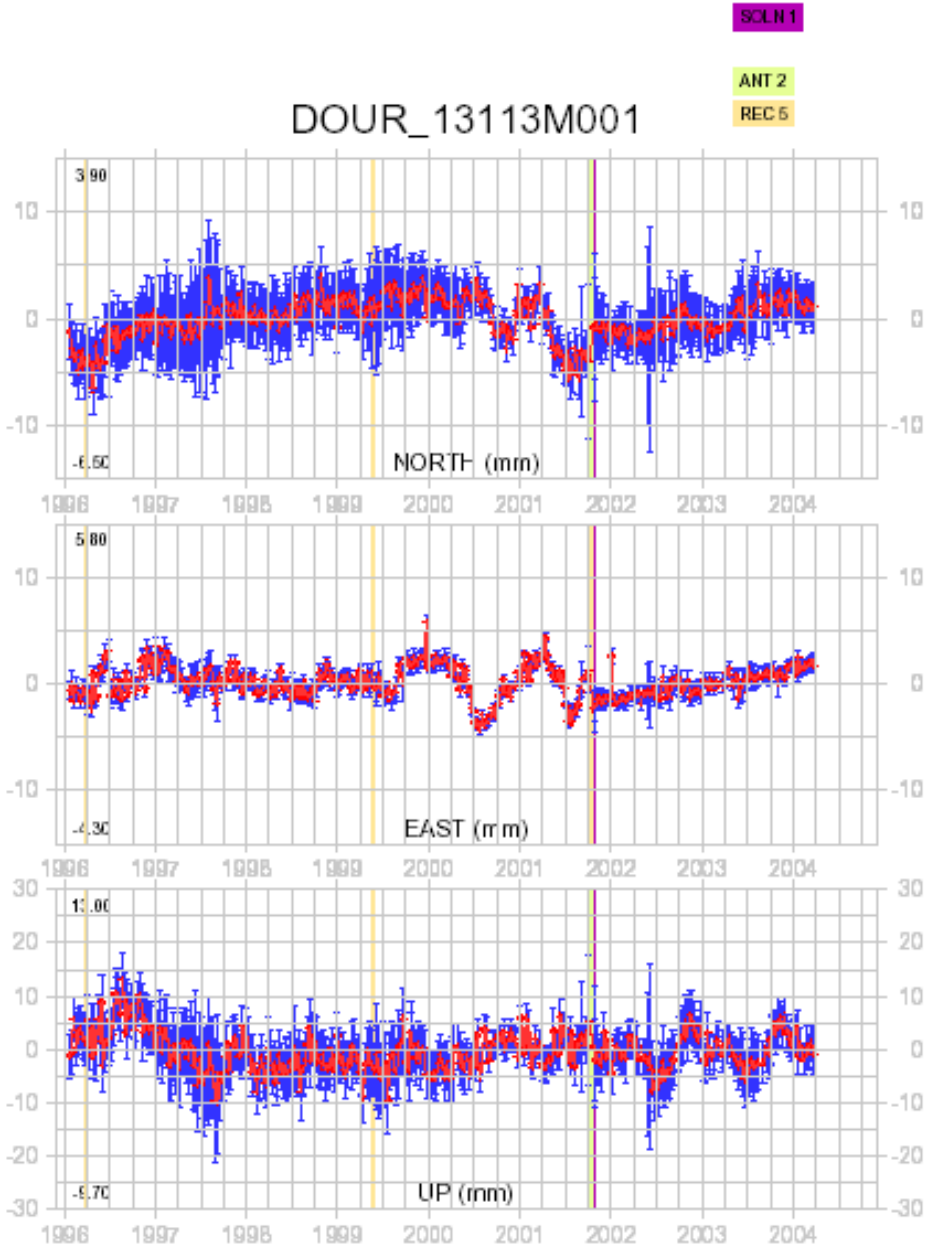
EPN ETRS89 Horizontal Velocities

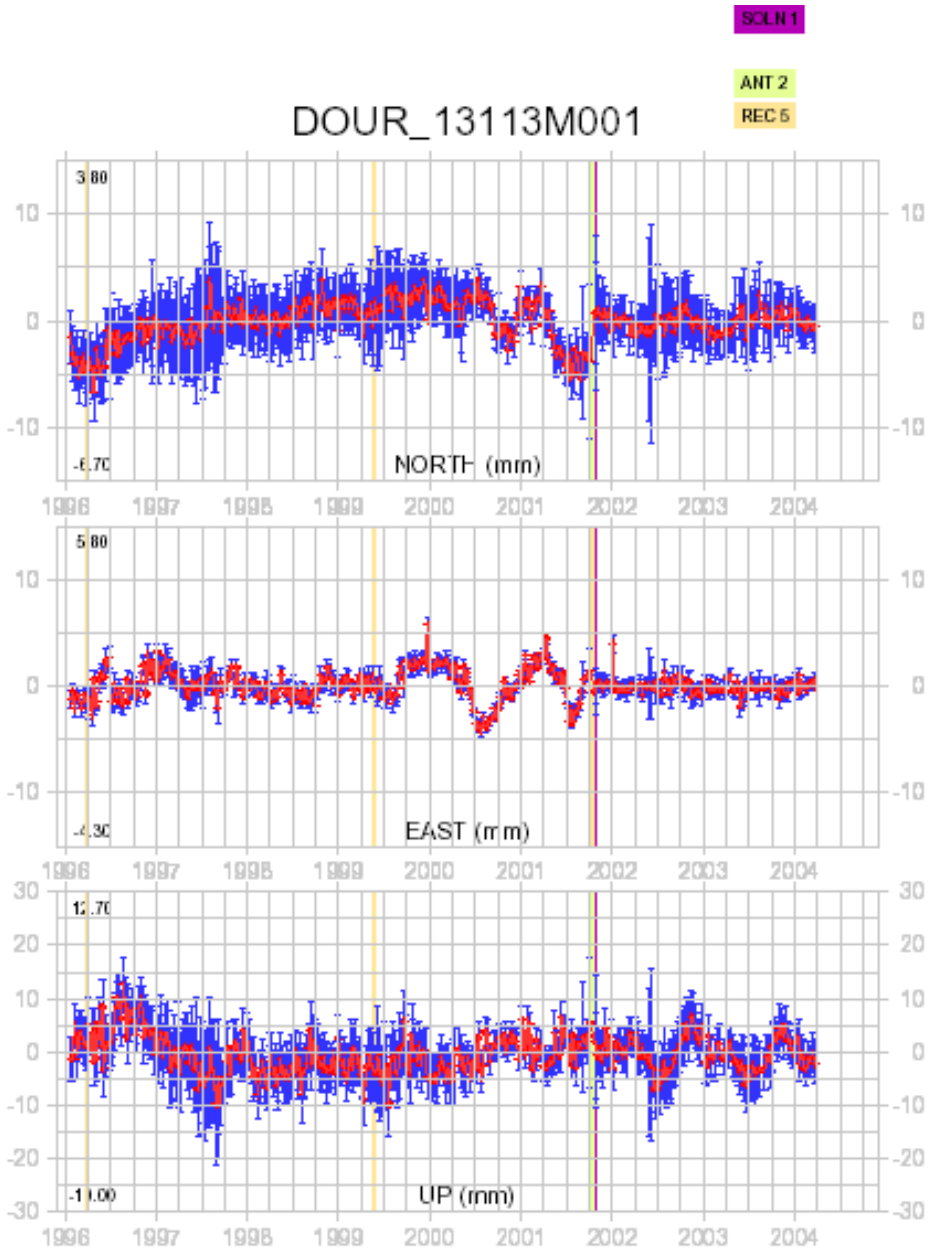
Handling discontinuities



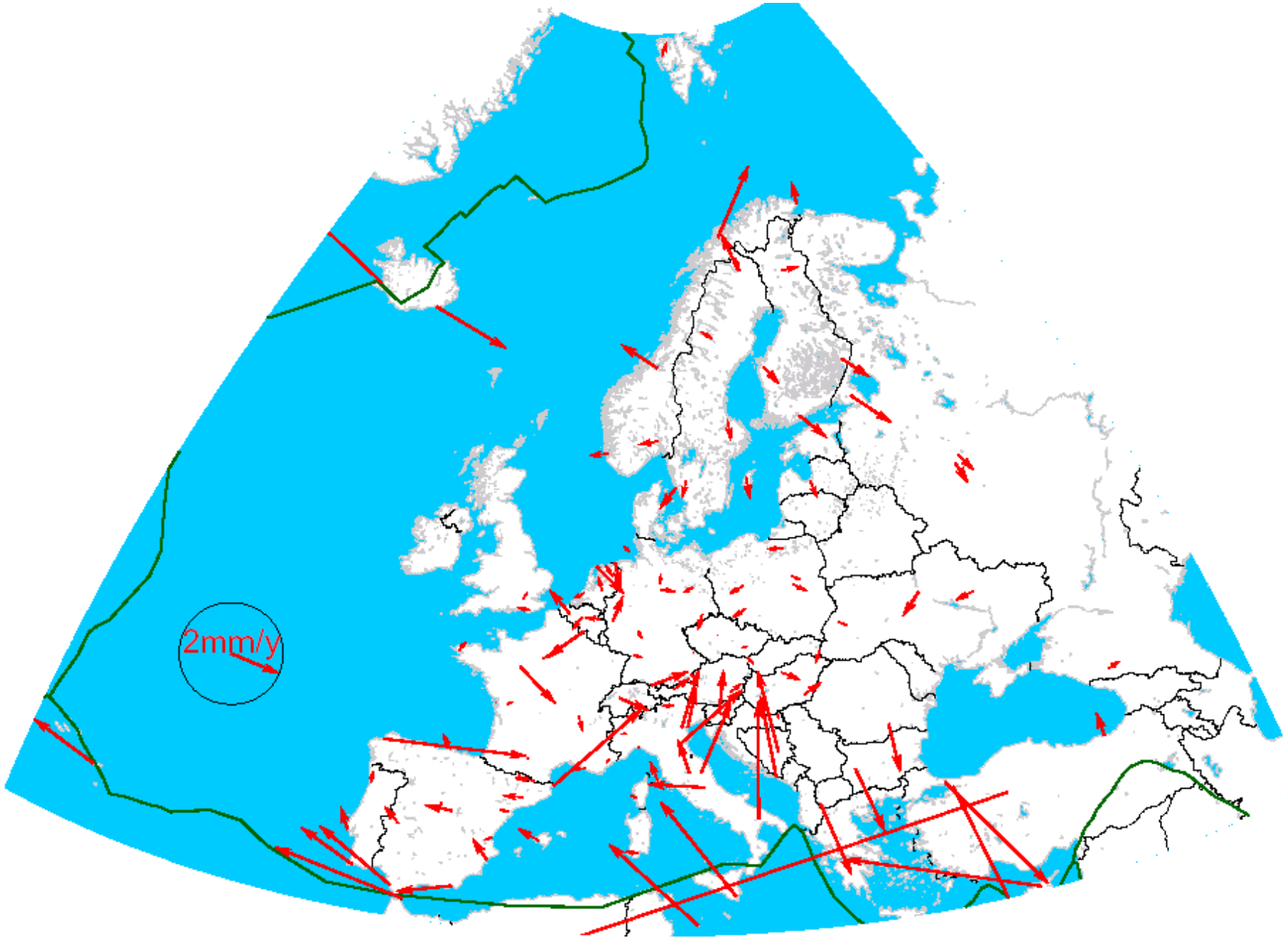


Handling discontinuities

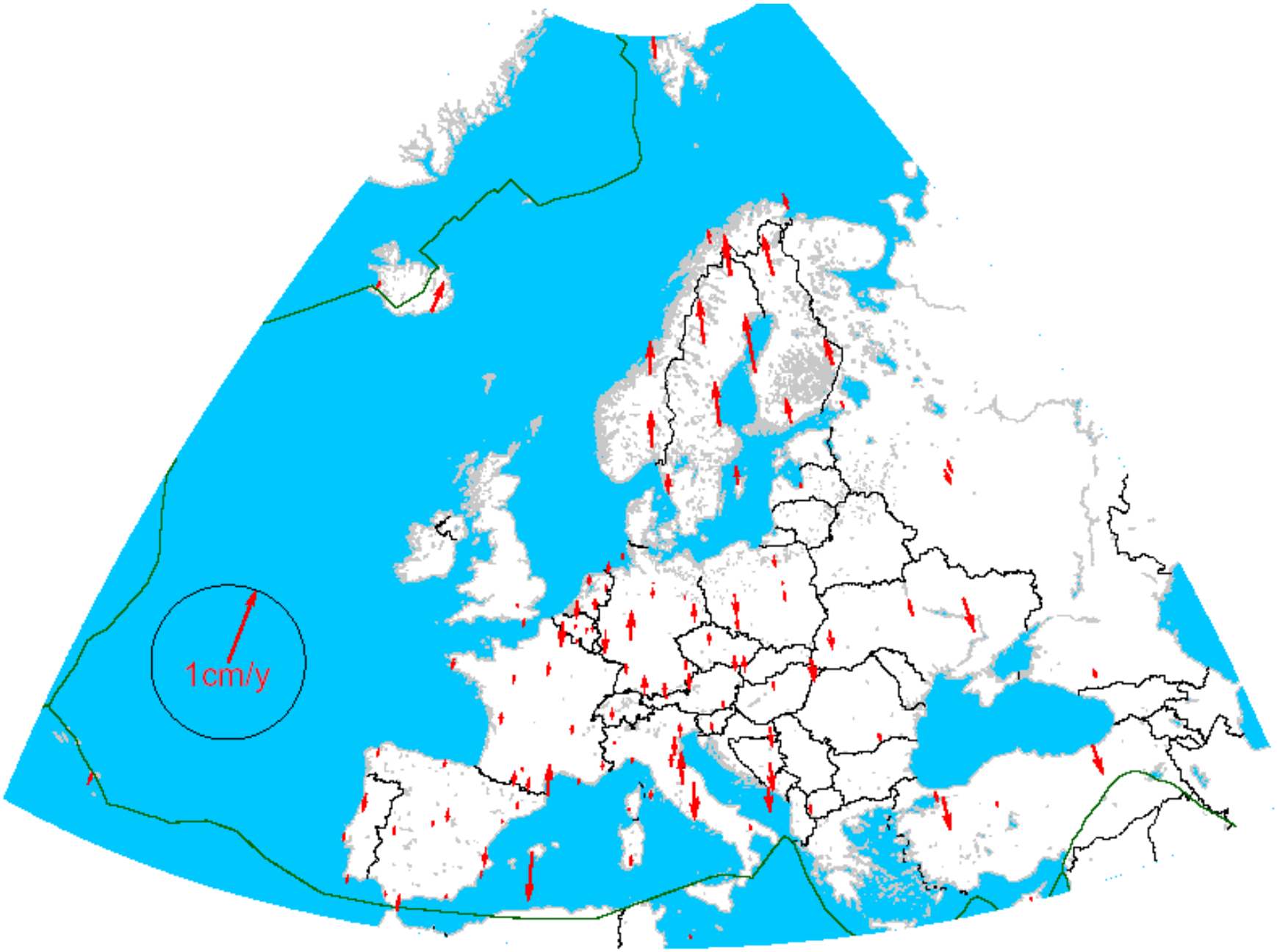




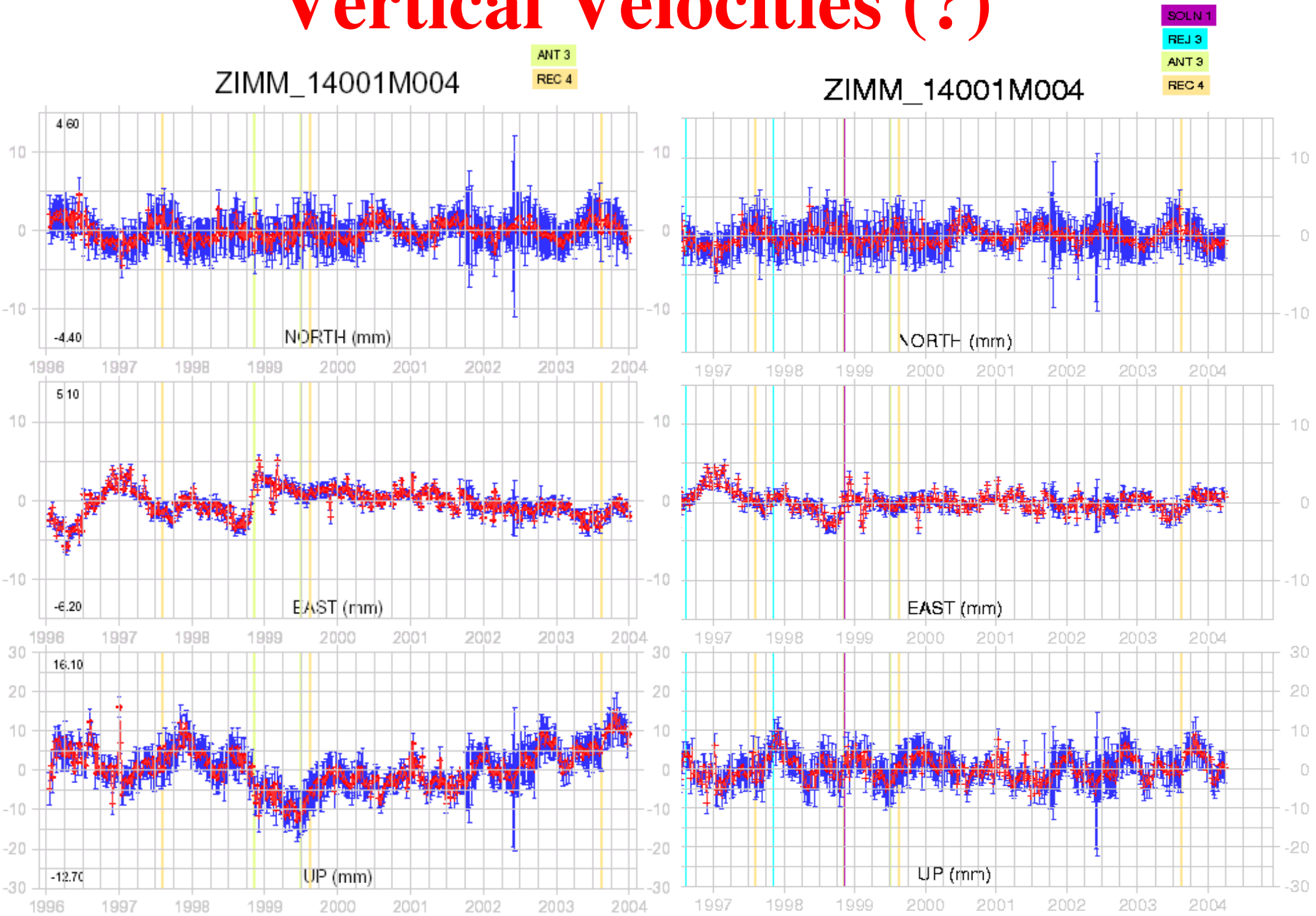
EPN ETRS89 Horizontal Velocities



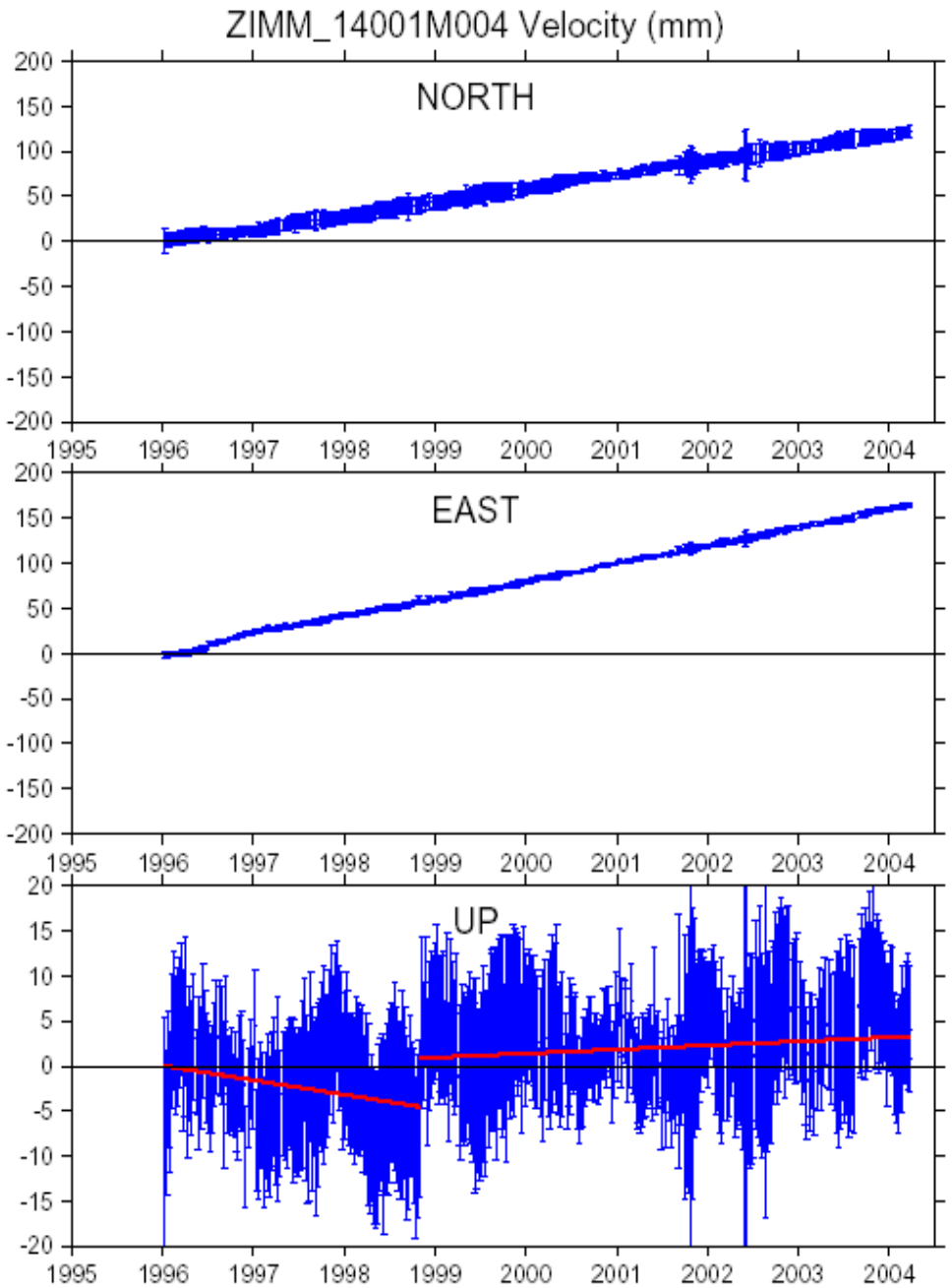
EPN ETRS89 Vertical Velocities

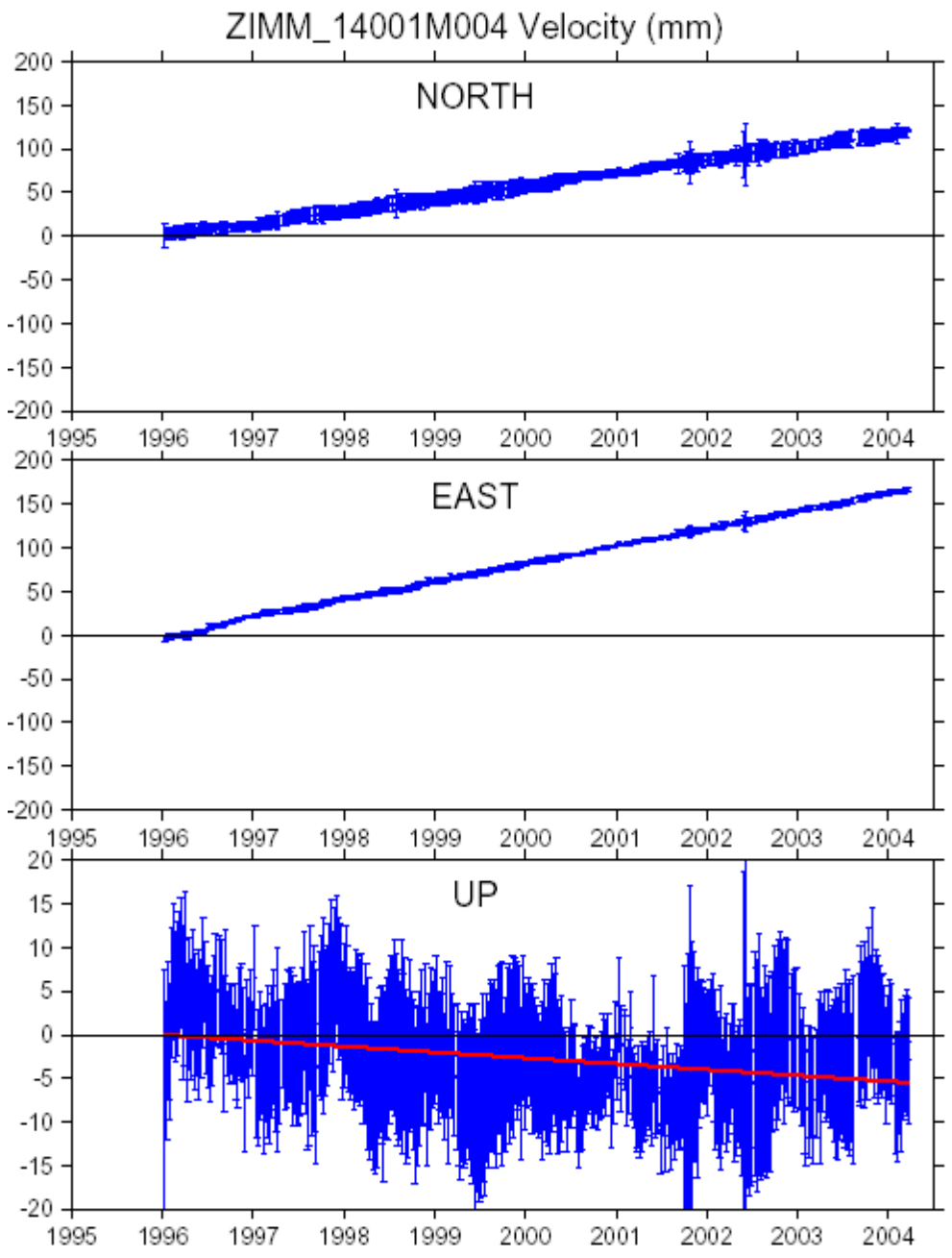


Vertical Velocities (?)

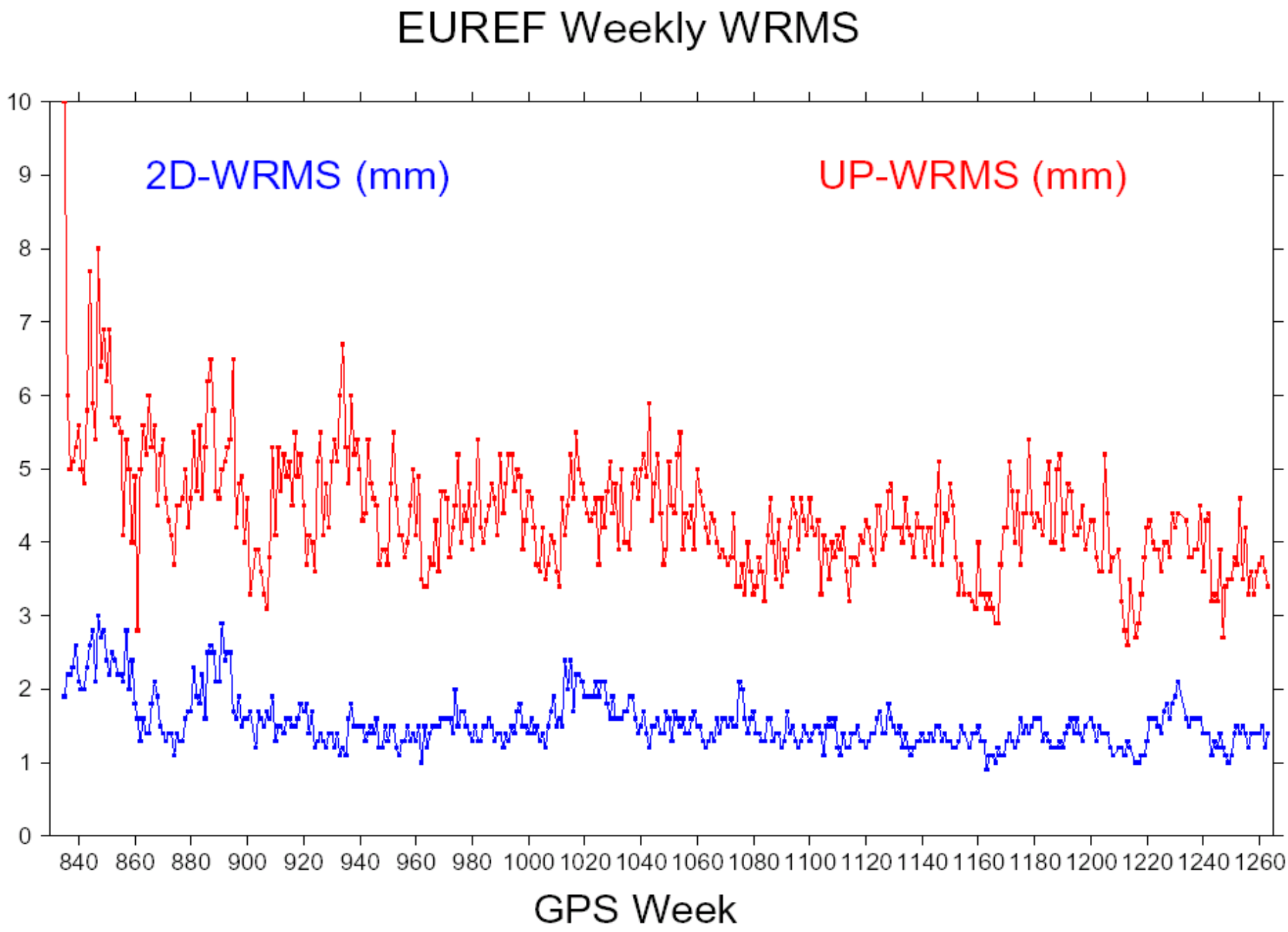


Vertical Velocities (?)



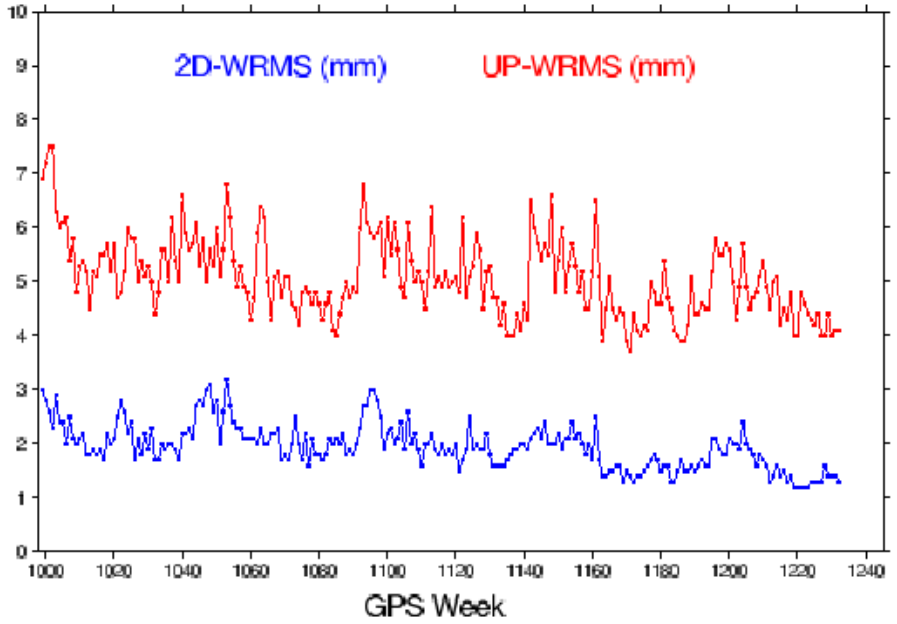


Quality Evaluation

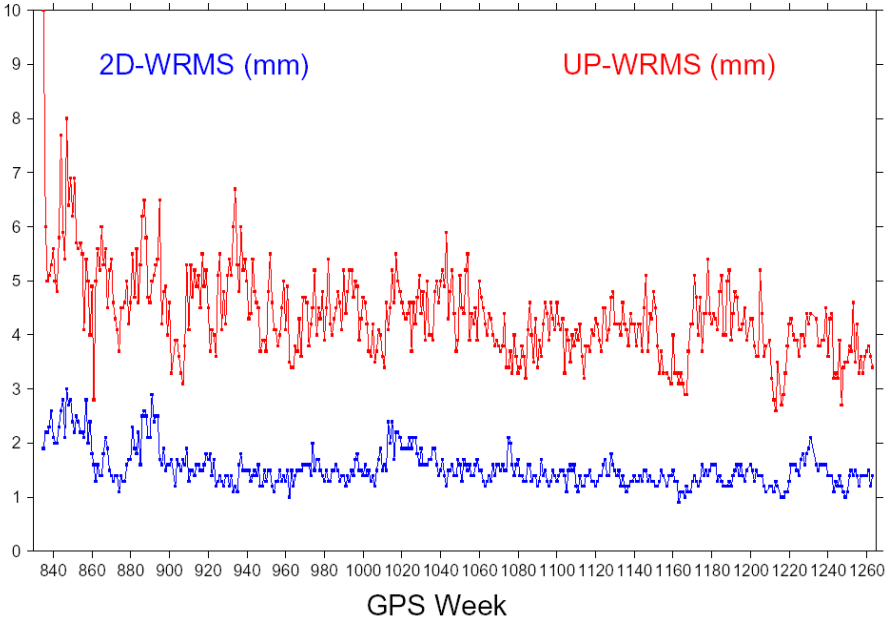


Quality Evaluation

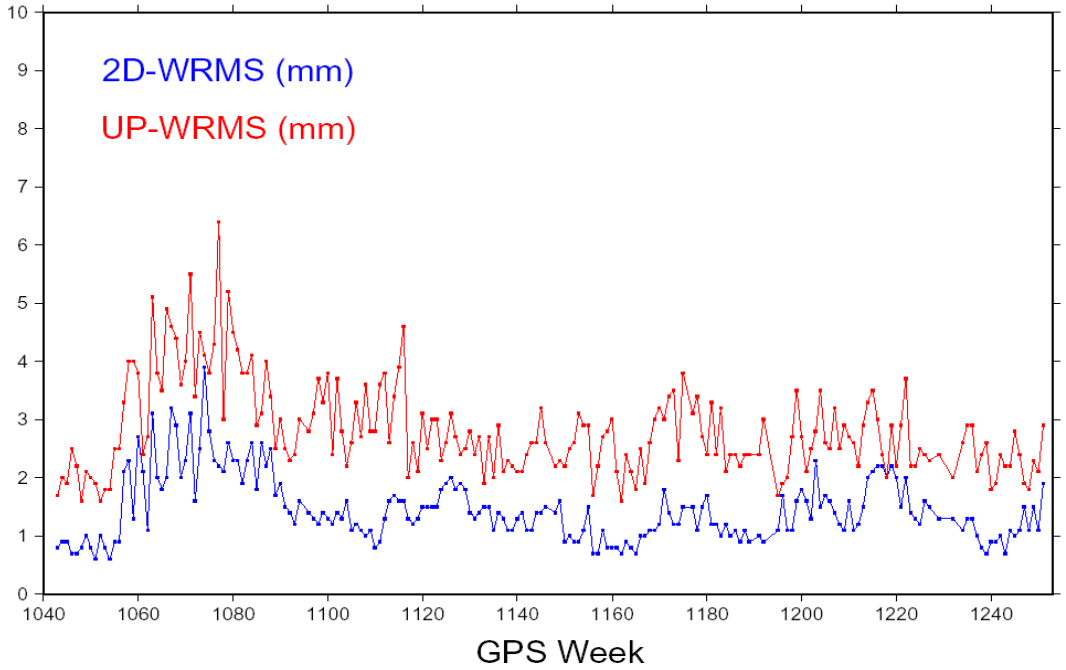
IGS Weekly WRMS



EUREF Weekly WRMS



RGP Weekly WRMS



Conclusions

- EPN-ETRS89 station positions & velocities will be available for users
- Updated regularly (annually)
- Dense velocity field will include other networks (national, local)
- Minimum constraints approach insure internal consistency
- EUREF Weekly WRMS:
  - 2 mm in horizontal
  - 4-5 mm in vertical
- Re-computing EUREF weekly solutions will certainly improve their quality