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F. GLOBAL AND REGIONAL KINEMATICS WITH VLBI

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The measurement of global and regional kinematics using VLBI begins with the definition of an observing program but does not end with the selection of the most appropriate analysis. Since a VLBI station cannot operate in isolation and since simultaneous operation of the entire VLBI network is impractical, it is necessary to design observing programs with periodic observing sessions using networks of 3-7 stations that, when treated together, will have the necessary interstation data and network overlaps to determine the desired rates of change. Thus there has been a mix of global, intercontinental, transcontinental, and regional networks to make measurements ranging from plate motions to deformation over a few hundred km. Over time, even the networks focusing on regional deformation using mobile VLBI included large stations removed by several thousand km to increase sensitivity, determine EOP more accurately, and provide better ties to the terrestrial reference frame (TRF). Analysis products have also evolved, beginning with baseline lengths, then broadening to the transverse and vertical baseline components, and then to full three-dimensional site velocities in a global TRF.

The type of analysis that simultaneously estimates site positions and velocities along with EOP values, thereby defining a TRF, has a number of variations. The Goddard Mark III Data Analysis System allows all the stations to move uniformly or any subset to move in a piecewise-linear, continuous fashion, to have a break such as caused by coseismic motion ("episodic motion"), to have step-wise positions (effectively averaging over some time interval), or to be unconstrained between sessions. The uniform velocity mode gives the most precise long-term answer while the other methods allow finer temporal resolution. The conceptual basis of this type of analysis is that there are enough sites moving in a simple manner to permit the definition of a TRF.

Another approach is to estimate the site positions and baseline components independently for each day and study the evolution of individual baselines and sites by plotting the time series. This approach provides the greatest detail in examining the data, and the baseline lengths are independent of the TRF. The scatter of baseline lengths about their best fit lines as a function of baseline length is 5 mm+2 ppb for all baselines and 1.2 mm+0.5 ppb for the best observing program. The transverse and vertical baseline components and site positions, whether Cartesian or topocentric, are strongly dependent on accurate EOP values, which in practice are derived from VLBI TRF solutions. The typical 1-sigma formal errors in EOP from the weekly NEOS-A network are 0.1 mas in pole component and 0.004 ms in UT1, while the best Space Geodesy Program errors are 0.05 mas in pole and 0.002 ms in UT1. Since VLBI fundamentally measures baseline vectors, some arbitrary definition is required to map the interstation vectors to site positions. The Mark III Data Analysis System has two options: to fix the position of one station in the network (used in the Goddard VLBI annual reports) or to minimize the sites' position residuals each day from a specified TRF (which gives minimal position scatter).

Figure 1 shows the horizontal site velocities around the Atlantic in the No-Net-Rotation (NNR) NUVEL-1 TRF. The 3-sigma error ellipses are drawn at the head of the measured vector, and the NNR NUVEL-1 vectors are also shown. Several points should be noted. Some of the error ellipses cannot be seen, being less than 1 mm/yr for some stations. Second, the stations at Fortaleza, Brazil and O'Higgins, Antarctica, have less than a year of data. Their errors are large but the values are interesting. Third, there are significant deviations from NNR NUVEL-1 such as Hartebeesthoek, South Africa; the Italian stations at Noto, Matera and Medicina; and Santiago, Chile.

Figure 2 shows the topocentric coordinates of Gilmore Creek, Alaska in two-month windows. The vertical wrms scatter is 10 mm and there is a roughly annual variation. The wrms scatter of the horizontal values is 3 mm. Gilmore Creek is now the most often used station with a session every 2.7 days on average in 1993. However, even the horizontal WRMS scatter at Santiago, with about 5 sessions in each 2-month window, is not worse than 9 mm.

Figure 3 shows the evolution of the Gilmore Creek to Yellowknife, Northwest Territories baseline components. The dashed line shows the expected rates for a rigid North American plate. There appears to be a significant upward motion of Yellowknife with respect to the other end, which is also seen in other Yellowknife baselines. The inferred site vertical rate at Yellowknife is in excess of 15 mm/yr with a 3-sigma error of 10 mm/yr.

VLBI measurements of global and regional kinematics have made major contributions to geophysics, demonstrating and quantifying the reality of present day plate motions and the complex regional deformations in Alaska, California, and the Mediterranean. While regional measurements with mobile VLBI are now history, there is an active program to extend accurate measurements to Australia, South America, and interior Eurasia using existing and recently constructed or equipped stations.

Transatlantic Velocities

NUVEL-NNR reference frame

99% confidence error ellipses

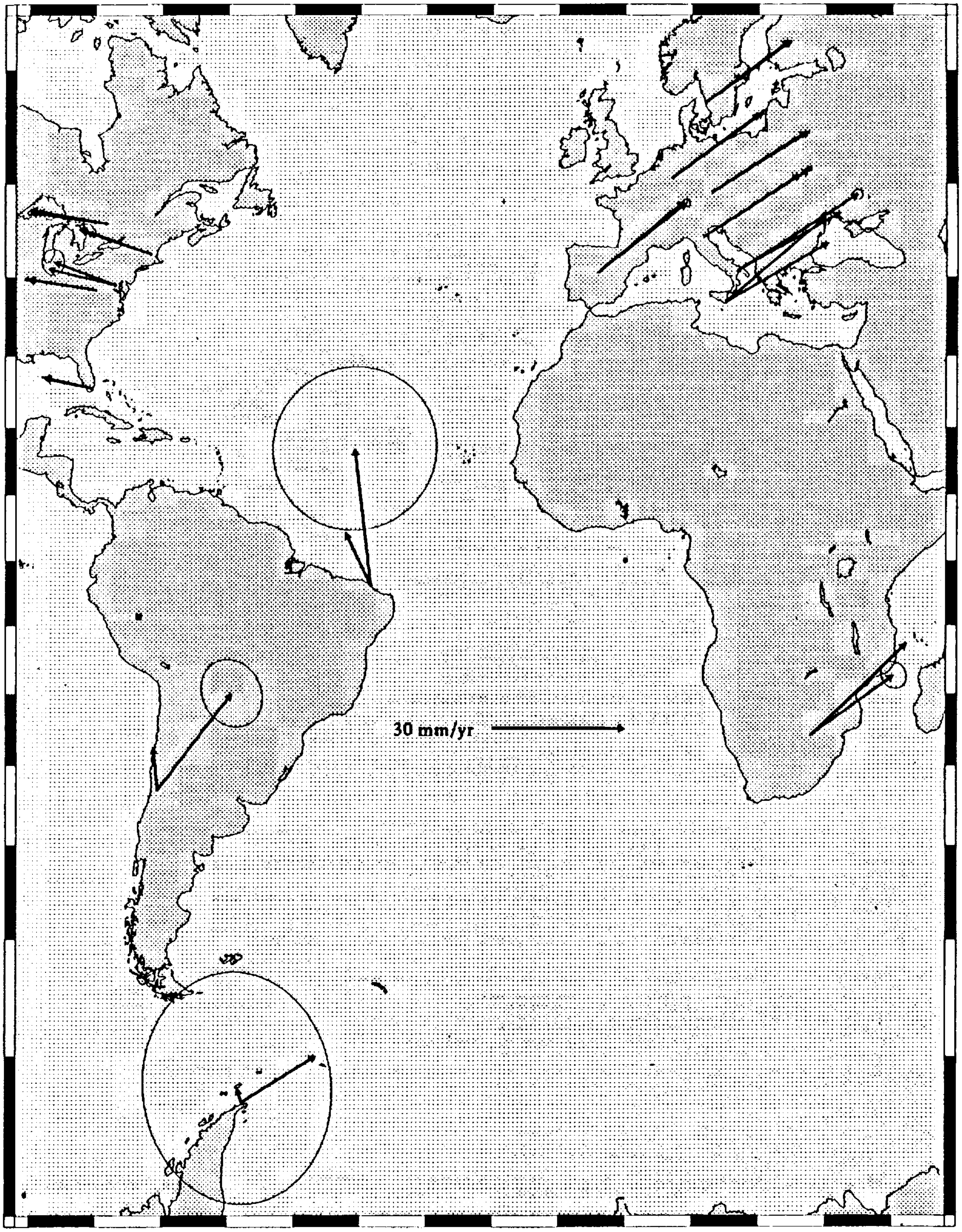
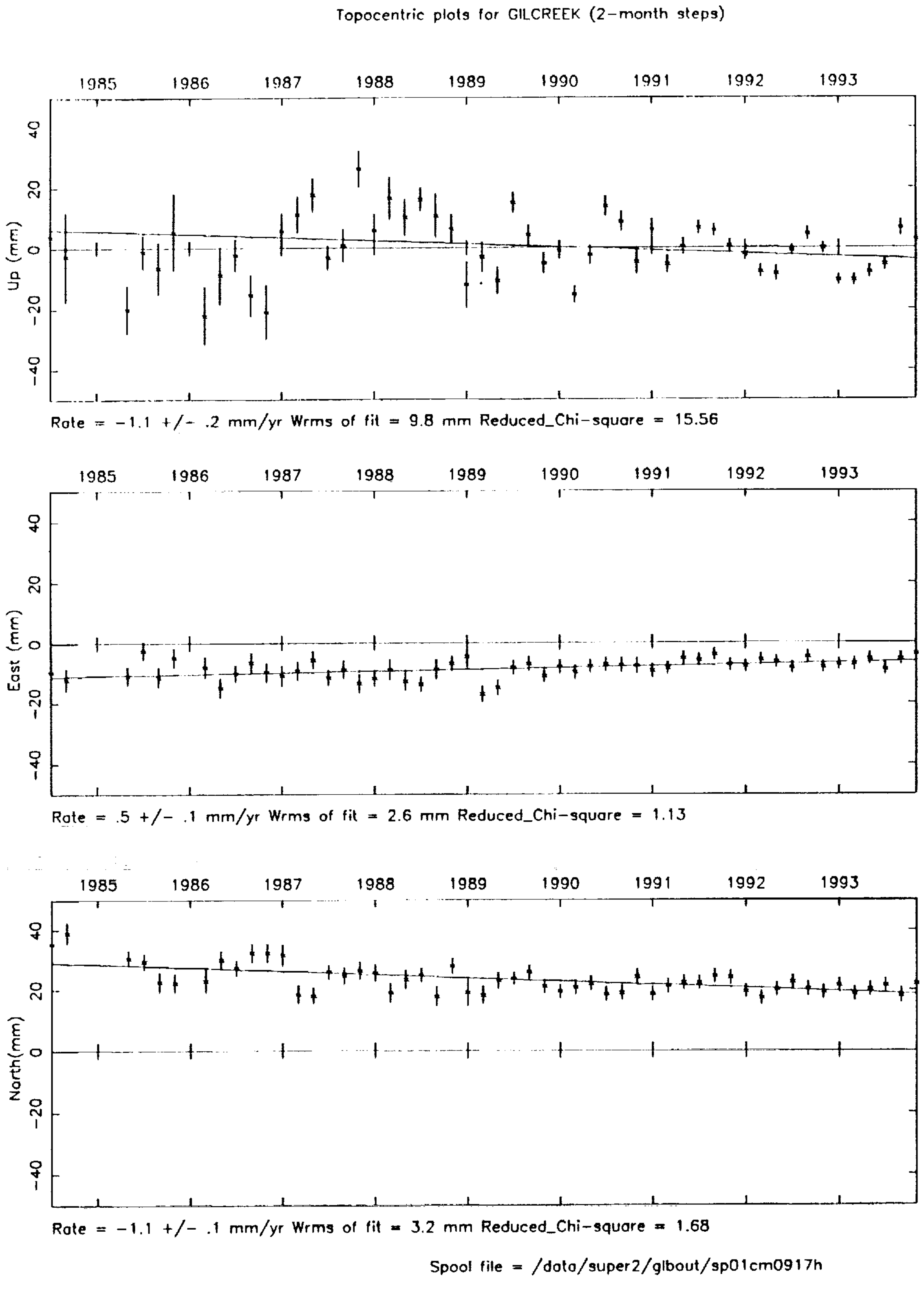


Figure 1.



Topocentric plots for GILCREEK (2-month steps)

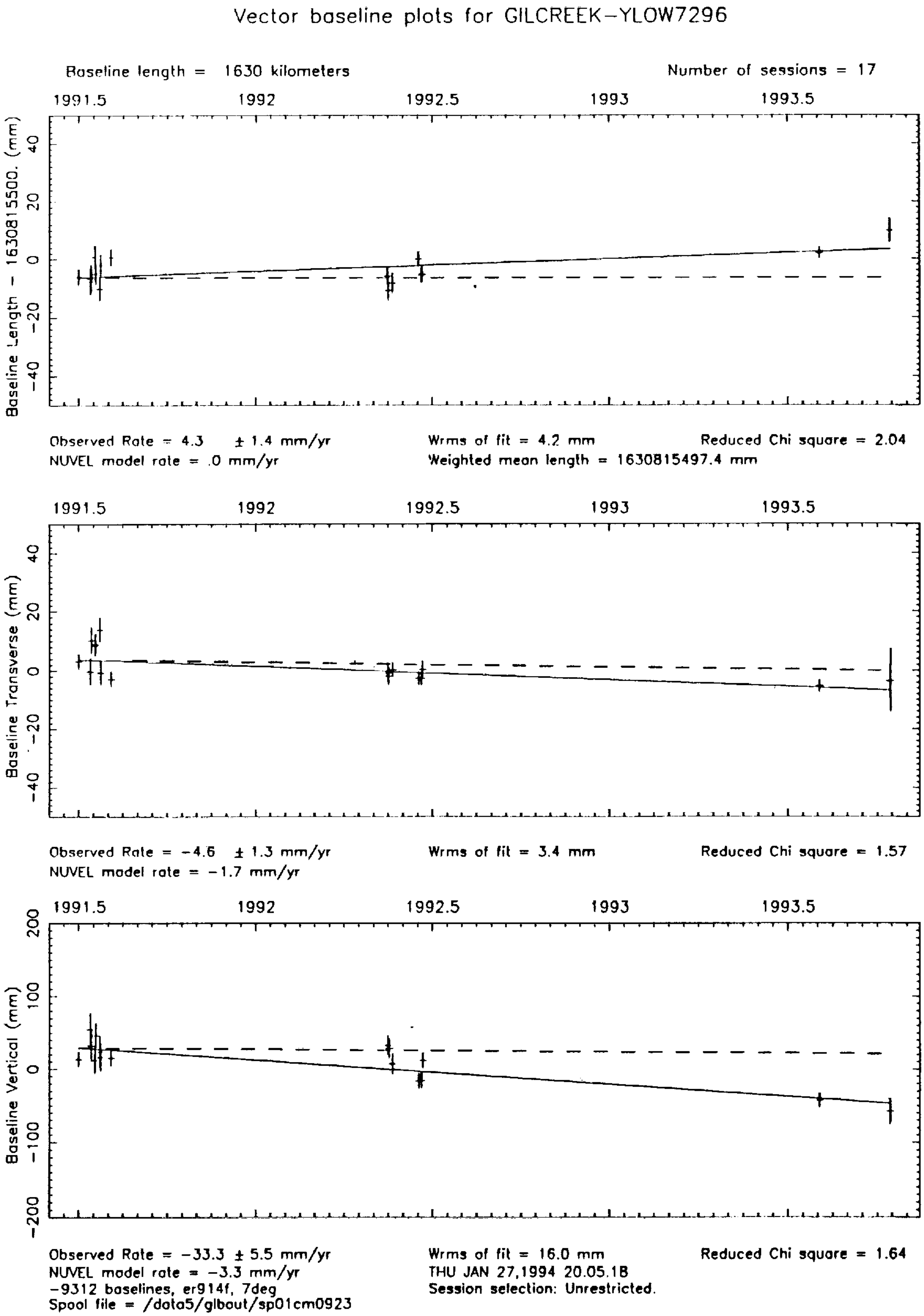
Rate = -1.1 +/- .2 mm/yr Wrms of fit = 9.8 mm Reduced_Chi-square = 15.56

Rate = .5 +/- .1 mm/yr Wrms of fit = 2.6 mm Reduced_Chi-square = 1.13

Rate = -1.1 +/- .1 mm/yr Wrms of fit = 3.2 mm Reduced_Chi-square = 1.68

Spool file = /data/super2/glbout/sp01cm0917h

Figure 2.



Vector baseline plots for GILCREEK-YLOW7296

Baseline length = 1630 kilometers
Number of sessions = 17

Observed Rate = 4.3 ± 1.4 mm/yr
NUVEL model rate = .0 mm/yr
Wrms of fit = 4.2 mm
Weighted mean length = 1630815497.4 mm
Reduced Chi square = 2.04

Observed Rate = -4.6 ± 1.3 mm/yr
NUVEL model rate = -1.7 mm/yr
Wrms of fit = 3.4 mm
Reduced Chi square = 1.57

Observed Rate = -33.3 ± 5.5 mm/yr
NUVEL model rate = -3.3 mm/yr
-9312 baselines, er914f, 7deg
Spool file = /data5/glbout/sp01cm0923
Wrms of fit = 16.0 mm
THU JAN 27,1994 20.05.18
Session selection: Unrestricted.
Reduced Chi square = 1.64

Figure 3.