JMR path delay assessment against TMI, SSM/I and ECMWF

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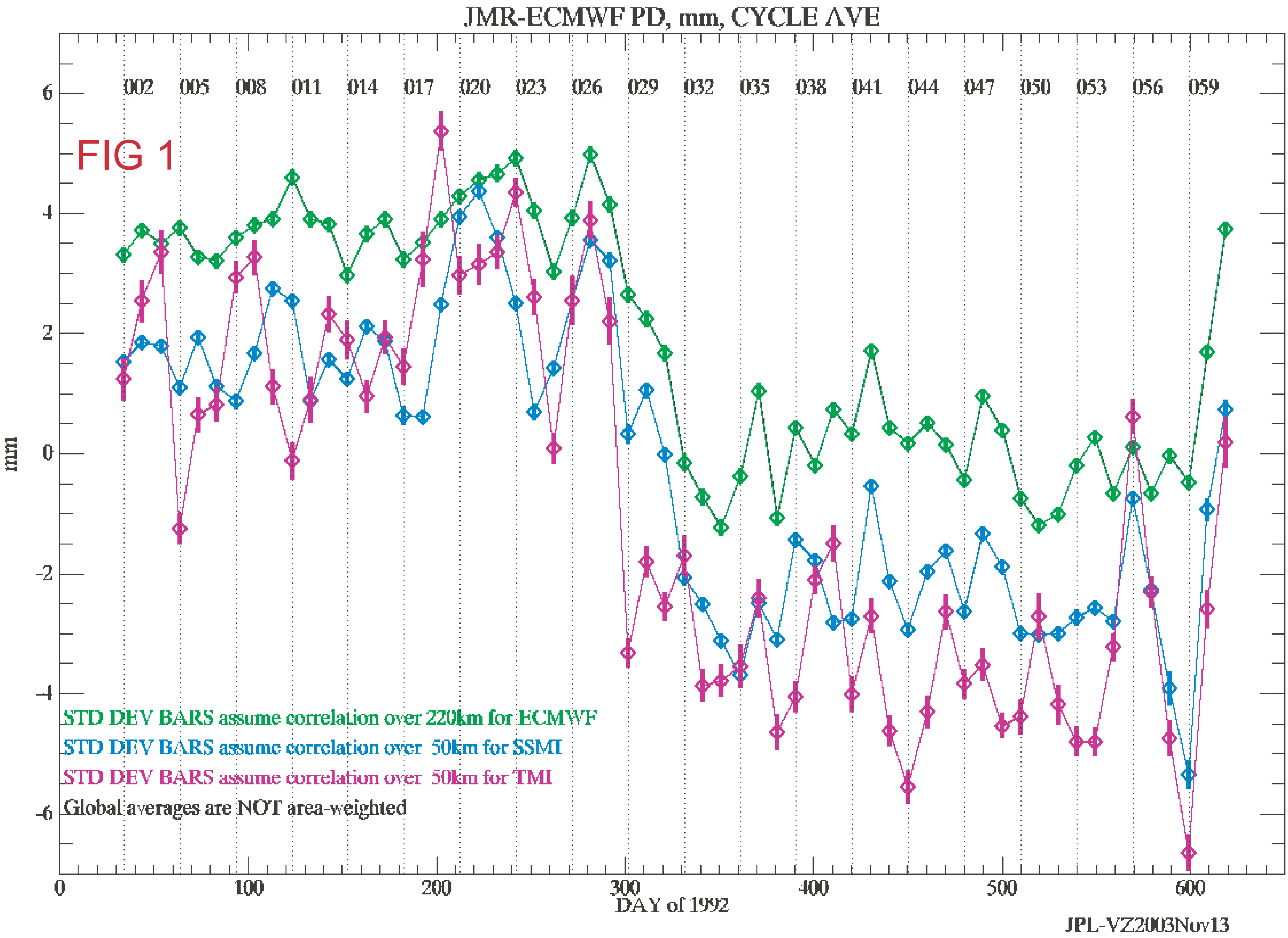
ABSTRACT & CONCLUSIONS

JMR, the microwave radiometer on Jason, provides a crucial correction for the path delay associated with water vapor.

TMR, the radiometer on TOPEX/POSEIDON, albeit with a different design than JMR, showed a drift between 1992 and about 1999, and a near 60-day periodicity associated with changes in spacecraft attitude linked to yaw steering mode.
This experience suggested the need to monitor JMR carefully and frequently.
We compare JMR to DMSP SSM/I and TRMM TMI as processed by Wentz et al, and to the ECMWF PD included in the GDR. A companion poster analyzes GPS-derived vapor

We find:
* JMR experienced a change around cycles 28-30 (October 2002) resulting in measured PD ~ 5mm shorter
* JMR experiences near 60 day changes associated with yaw steering, of ~3mm PD during 2003, smaller in 2002.
* JMR experienced a strong change over cycles 60,61 (~ Sept 2003) leading to a lengthening PD of ~ 5mm
* The combination SSM/I, TMI, ECMWF and GPS vapor overcomes difficulties with either data set in monitoring JMR



JMR-ECMWF PD, mm, CYCLE AVE
002
005
008
011
014
017
020
023
026
029
032
035
038
041
044
047
050
053
056
059
FIG 1
mm
6
4
2
0
-2
-4
-6
0
100
200
300
400
500
600
DAY of 1992
STD DEV BARS assume correlation over 220km for ECMWF
STD DEV BARS assume correlation over 50km for SSMI
STD DEV BARS assume correlation over 50km for TMI
Global averages are NOT area-weighted
JPL-VZ2003Nov13

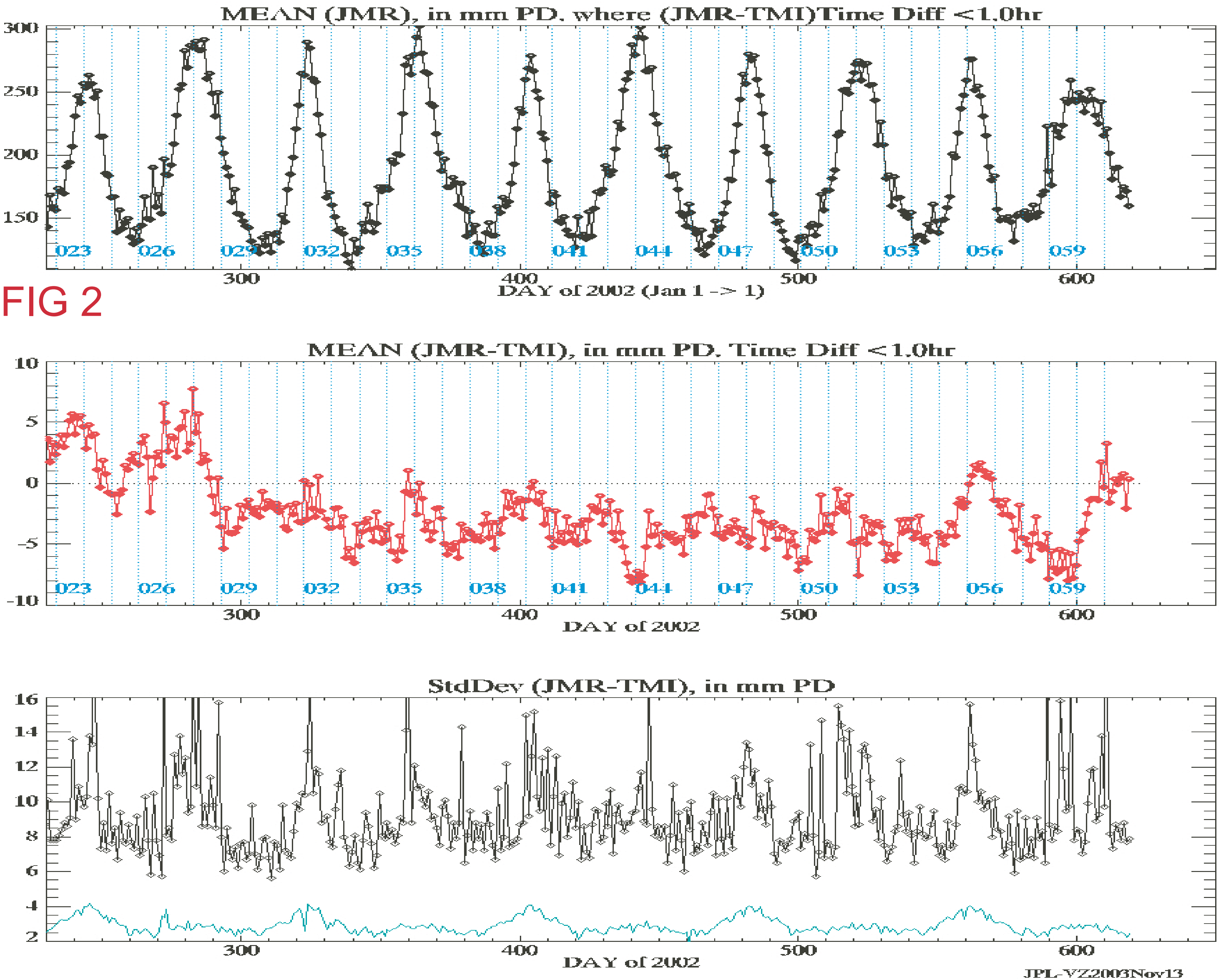
CYCLE AVERAGED DIFFERENCES IN PATH DELAY

Figure 1 summarizes several conclusions. Each point is a cycle-average (along the satellite track, not an area average) of the differences JMRpd - Xpd, where 'pd' is positive path delay, in mm, and X is one of SSMI, TMI or ECMWF.

All 3 curves show the downward 5 mm step around cycle 29, and the upward 'jump' at cycle 60. There is also a hint of a near-60 day periodicity in 2003 (every approx. 60 days the yaw regime of Jason is changed from sinusoidal to fixed, as was done for T/P).

The 2 mm differences between methods (JMR-SSM/I vs JMR-ECMWF) are also interesting, as they point to the accuracy of the comparison, regardless of the 'error bars', based only on the statistical variability of the differences, and an assumption as to correlation scales (50 km for the radiometers, 220 km for the ECMWF model output), which determines the number of degrees of freedom each cycle-average has.

FIG 2



MEAN (JMR), in mm PD. where (JMR-TMI)Time Diff <1.0hr
DAY of 2002 (Jan 1 -> 1)
MEAN (JMR-TMI), in mm PD. Time Diff <1.0hr
DAY of 2002
StdDev (JMR-TMI), in mm PD
DAY of 2002
JPL-VZ2003Nov13

TMI DAILY AVERAGED

Figure 2 shows 1-day averages of JMRpd (top), JMR-TMIpd (mid), and the standard deviation of JMR-TMI (bott), for their MATCHED POINTS (where JMR and TMI were within 12.5km and 1 hr).

As the top figure shows, there is a periodicity to the values the matched points see, but the middle plot clearly shows the differences do not correlate with the top plot.

The finer detail provided by the 1 day averages shows the behaviour during fixed yaw periods, although the noise level is high.

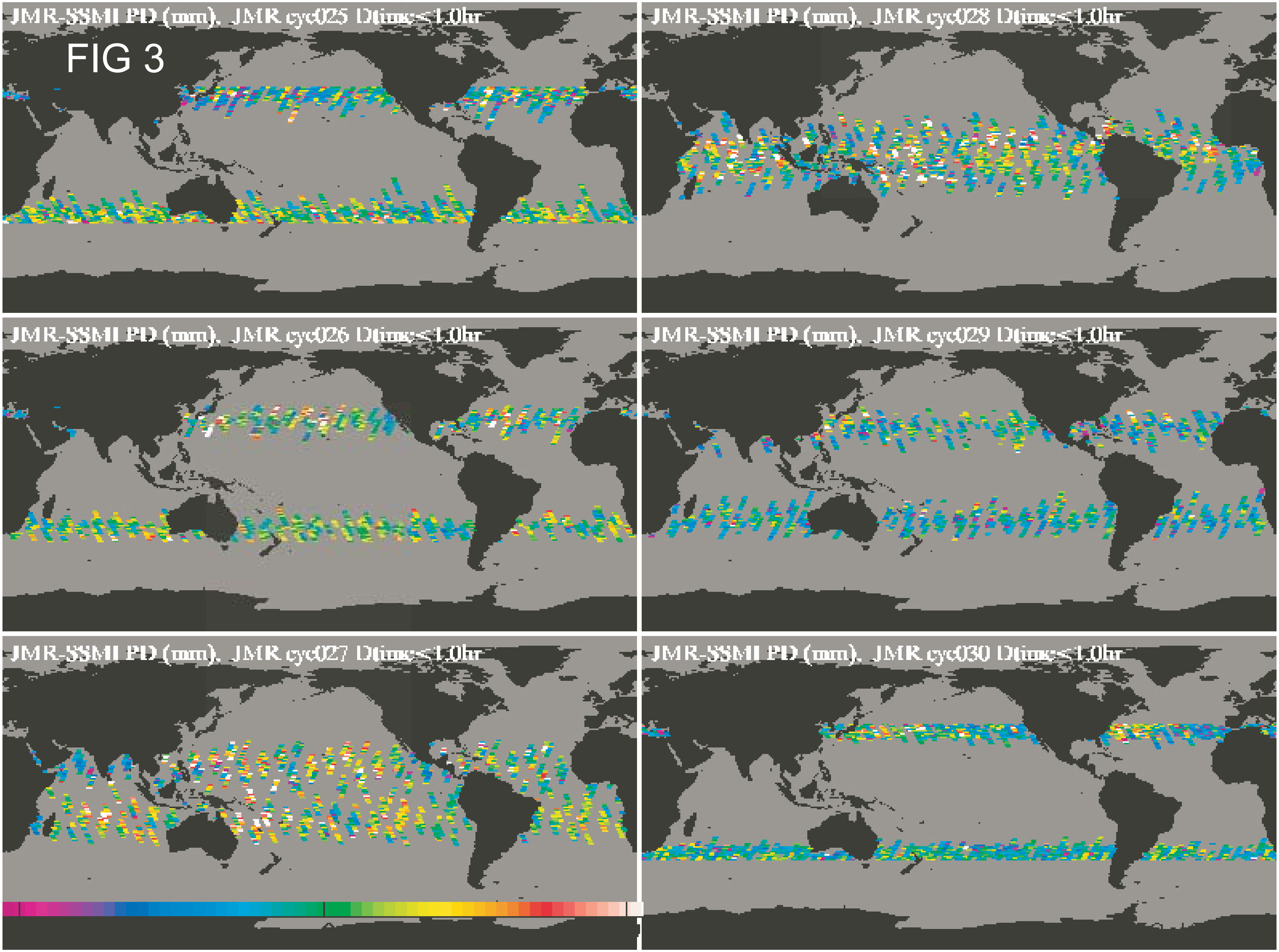


FIG 3
JMR-SSMI PD (mm), JMR cyc025 Dtime<1.0hr
JMR-SSMI PD (mm), JMR cyc028 Dtime<1.0hr
JMR-SSMI PD (mm), JMR cyc026 Dtime<1.0hr
JMR-SSMI PD (mm), JMR cyc029 Dtime<1.0hr
JMR-SSMI PD (mm), JMR cyc027 Dtime<1.0hr
JMR-SSMI PD (mm), JMR cyc030 Dtime<1.0hr

JMR-TMI MATCHES

The maps in Figure 3, one per Jason cycle, better show the spatial pattern of the matched JMR-TMI points, and their recurrence.

While TRMM is not in a sun-synchronous orbit, as the DMSP satellites are, both the JMR-TMI and the JMR-SSM/I spatial pattern of matched points has a strong 60 day cycle (the periodicity of β', the angle between Jason's orbital plane and the Sun-Earth line).

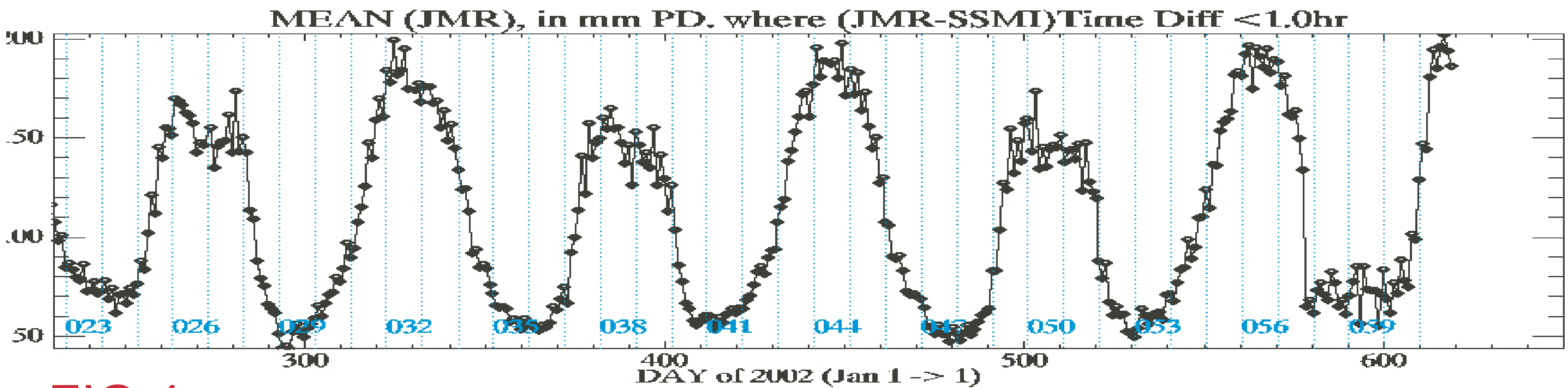
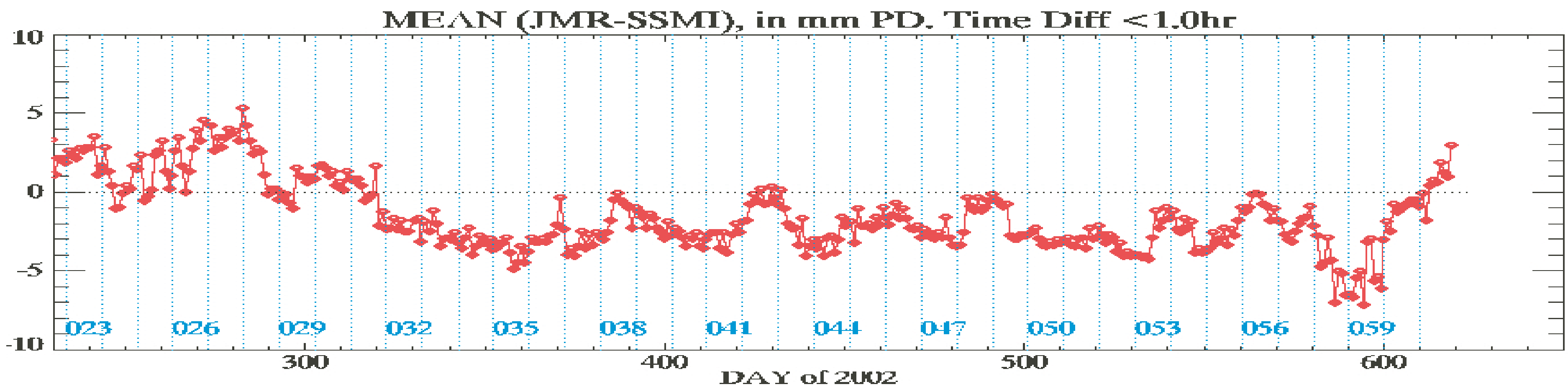
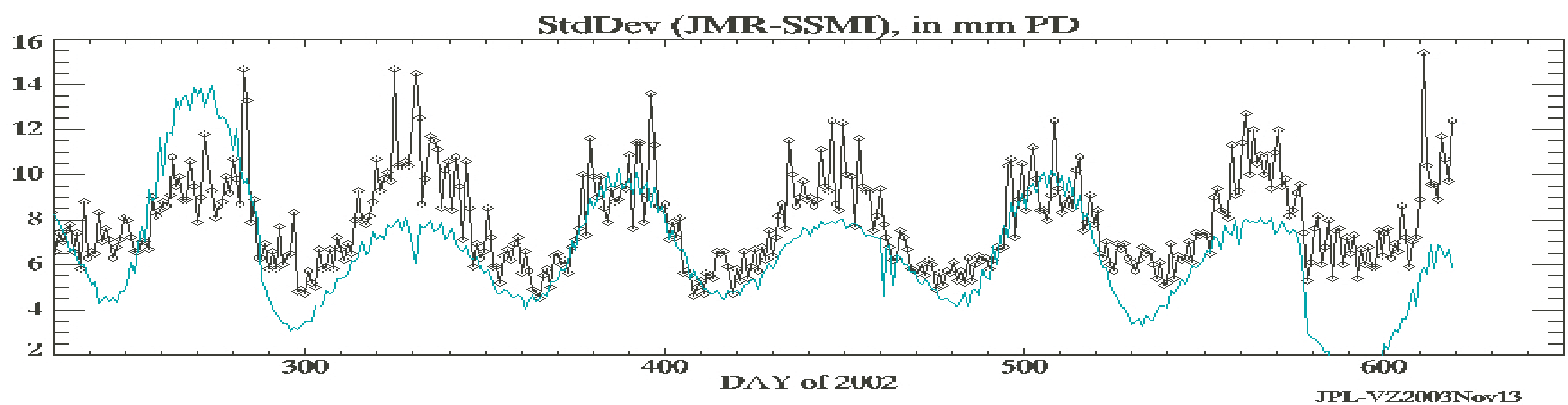

MEAN (JMR), in mm PD, where (JMR-SSMI)Time Diff <1.0hr
DAY of 2002 (Jan 1 -> 1)
023
026
029
032
035
038
041
044
047
050
053
056
059
300
400
500
600

FIG 4


MEAN (JMR-SSMI), in mm PD, Time Diff <1.0hr
DAY of 2002
10
5
0
-5
-10
023
026
029
032
035
038
041
044
047
050
053
056
059
300
400
500
600


StdDev (JMR-SSMI), in mm PD
DAY of 2002
16
14
12
10
8
6
4
2
300
400
500
600
JPL-VZ2003Nov13

SSM/I DAILY AVERAGES

Figure 4 is equivalent to figure 3, but using SSM/I instead of TMI.

TRMM is a single satellite. For the SSM/Is we have available data for 3 DMSP satellites which are currently on orbit. This is best seen in the bottom plot, whose stamdard deviations are lower than for JMR-TMI differences.

Notice the very clear regime changes at cycles 47-48 and 53-54.

The worrysome feature of this plot is the upward trend at cycle 60, a clear departure from the JMR behaviour since cycle 30.

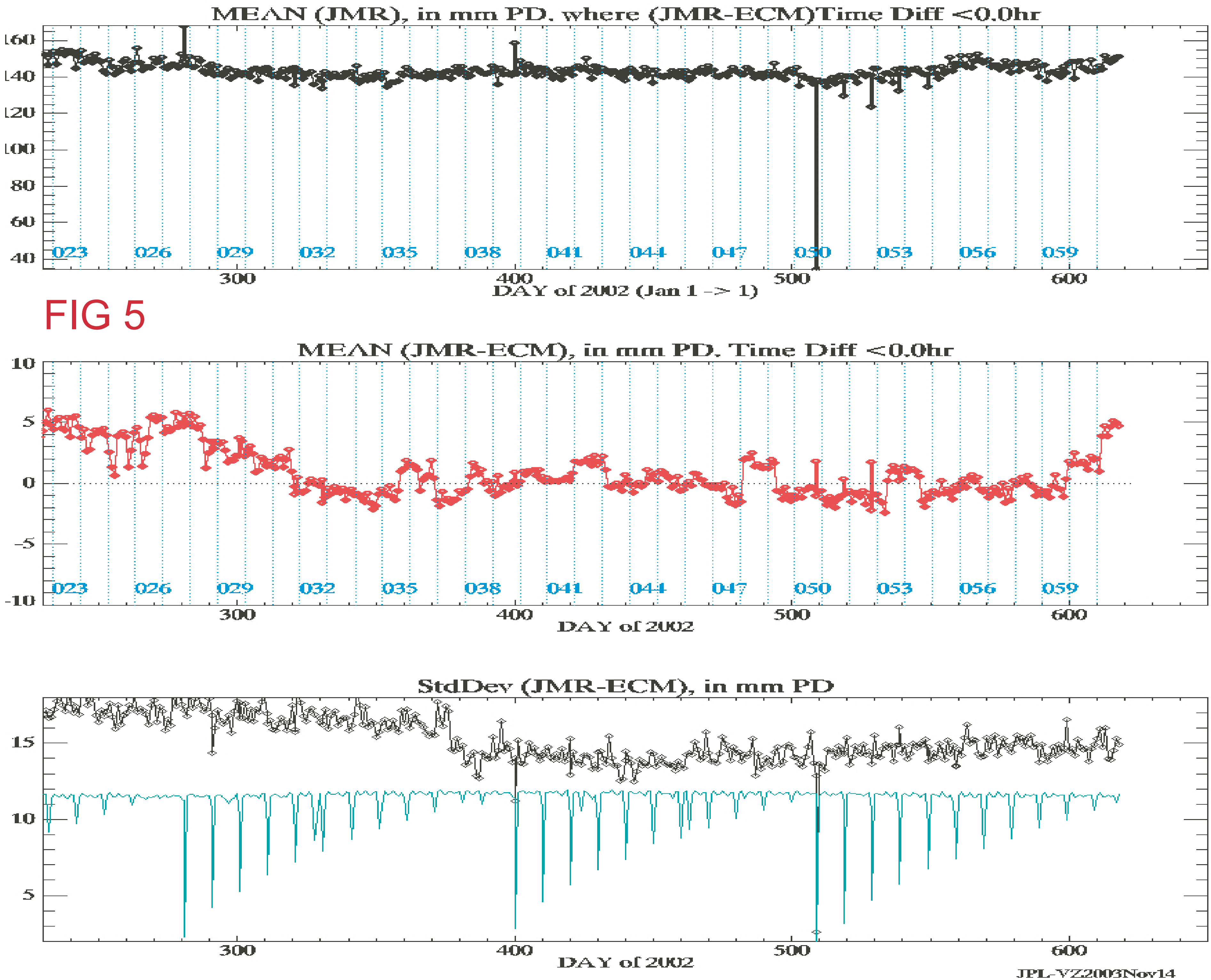
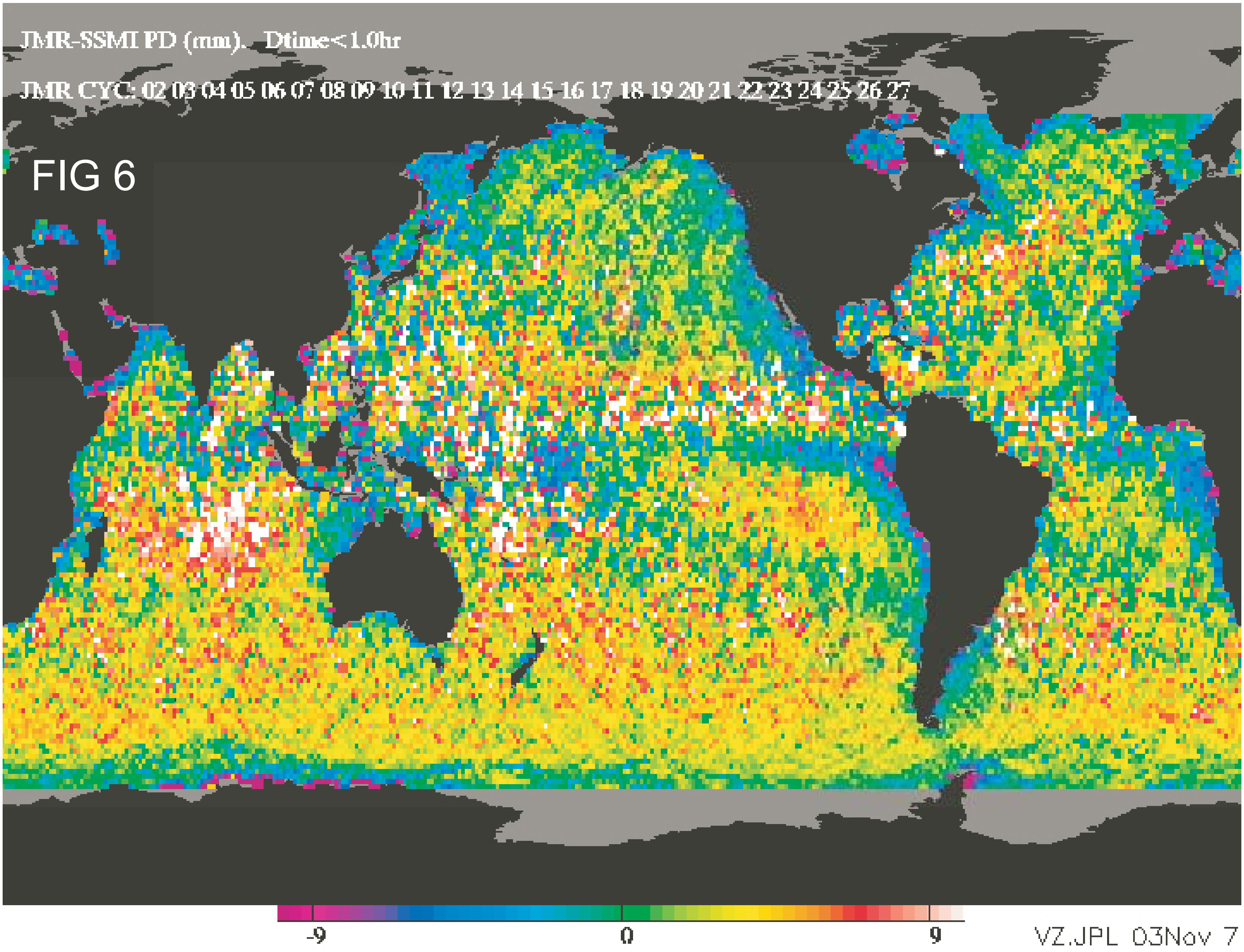

MEAN (JMR), in mm PD. where (JMR-ECM)Time Diff <0.0hr
DAY of 2002 (Jan 1 -> 1)
MEAN (JMR-ECM), in mm PD. Time Diff <0.0hr
DAY of 2002
023 026 029 032 035 038 041 044 047 050 053 056 059
StdDev (JMR-ECM), in mm PD
DAY of 2002
JPL-VZ2003Nov14

FIG 5

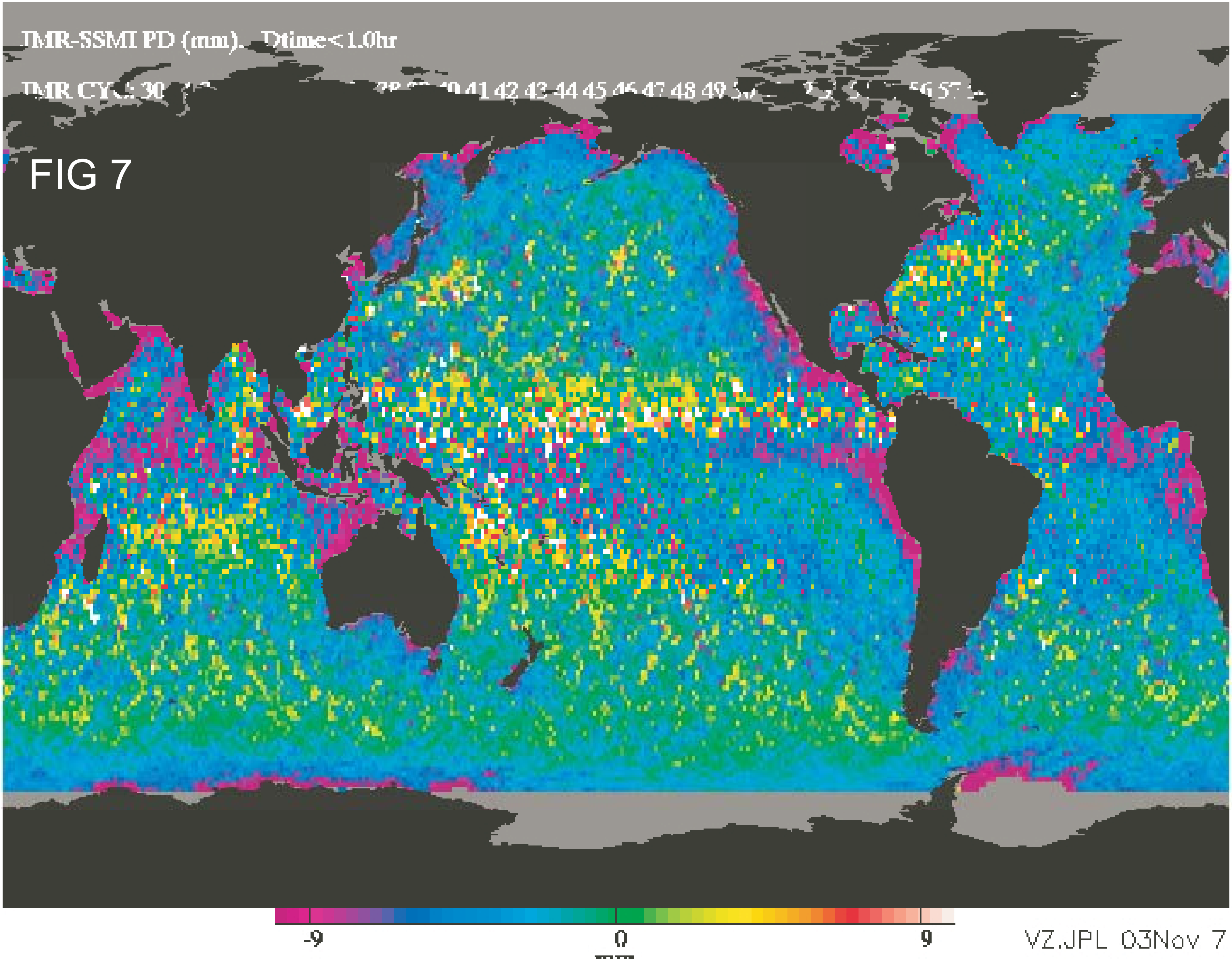
ECMWF DAILY AVERAGED

Figure 5 has the same format as those with daily-averaged JMR-TMI or JMR-SSMI, but uses the ECMWF-derived path delay from the Jason GDRs instead.

Note the higher standard deviation relative to either JMR-TMI or JMR-SSMI in 2002, before day 280. Also note the decrease in 2003. ECMWF is a model that changes as improvements are implemented. That makes it idfficult to decide when a bias change is due to ECMWF and when to JMR. In this case, only the standard deviation is affected. Interestingly, the standard deviation of JMR-ECMWF is now close to the nominal error budget of JMR itself.



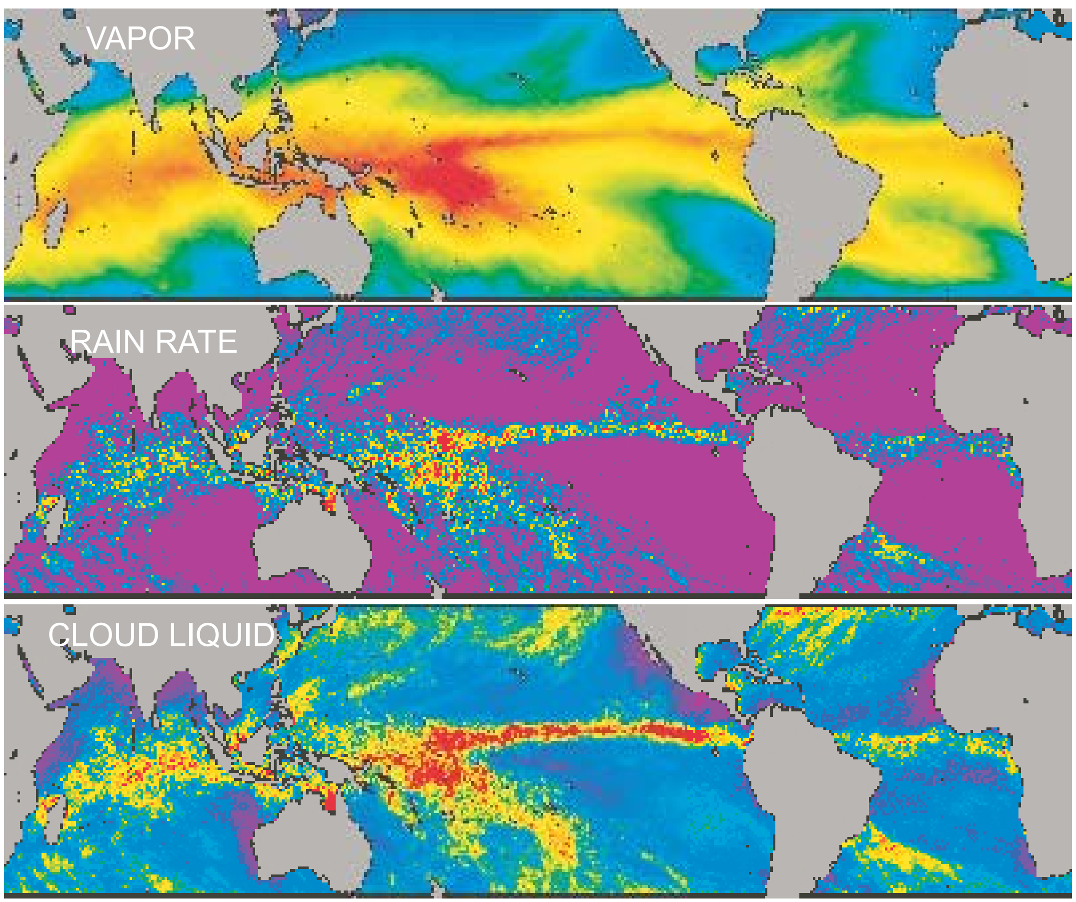
JMR-SSMI PD (mm). Dtime<1.0hr
JMR CYC: 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
FIG 6
-9
0
mm
9
VZ.JPL 03Nov 7


JMR-SSMI PD (mm). Dtime<1.0hr
FIG 7
-9
0
9
VZ.JPL 03Nov 7

MAPS OF JMR-SSM/I PD AVERAGED OVER CYCLES 2-27, 30-60

The maps in Figs 6 and 7 show the geographic pattern of the difference JMR-SSMI, averaged over all cycles before the JMR regime change around cycle 29, and after.

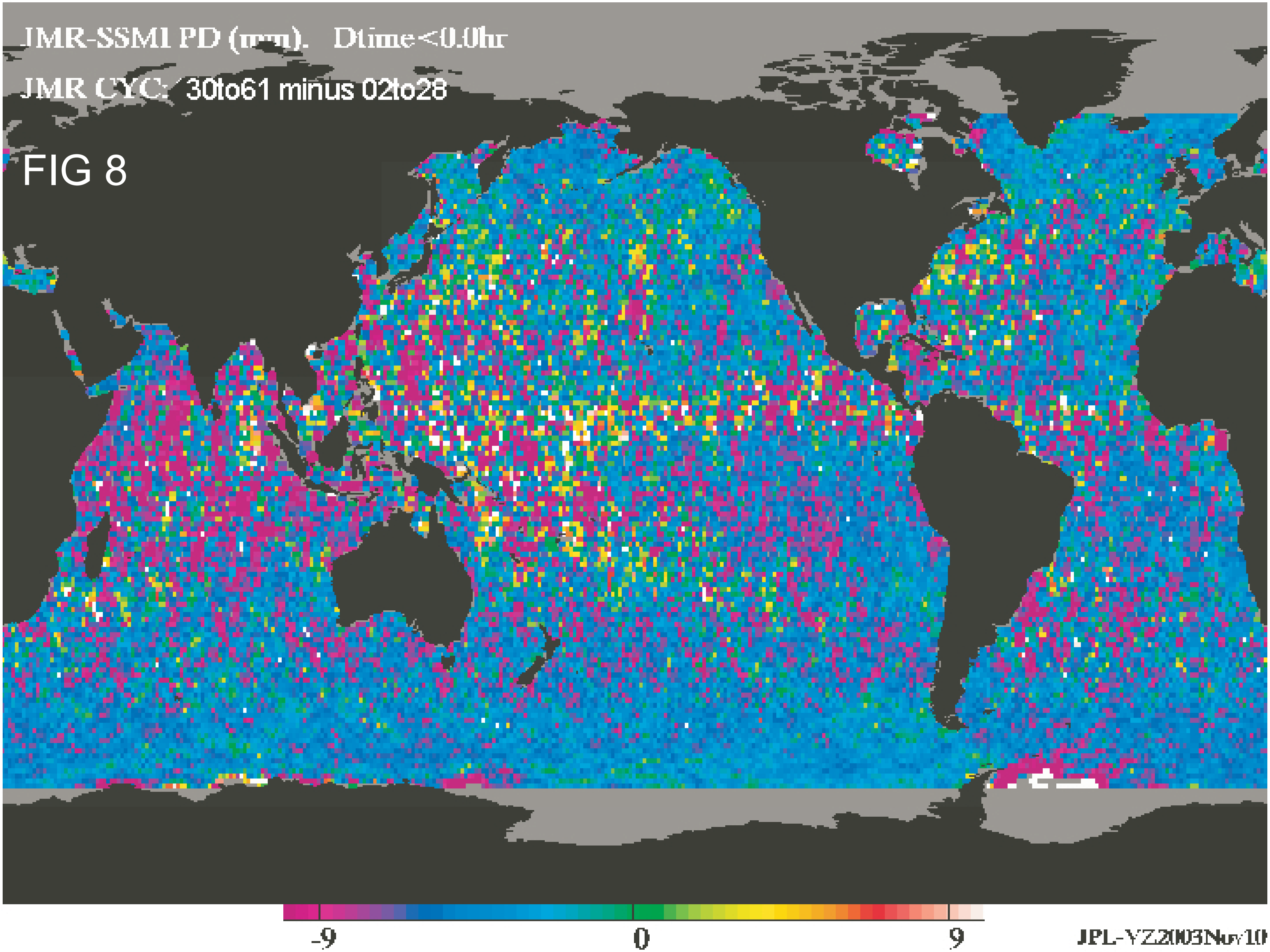
For comparison, the small inset maps below shows total vapor, precipitation rate and cloud liquid water from TMI, Jan 2003



The JMR-SSMI differences correlate with vapor, but also with cloud liquid and even with rainfall, all of which are retrieved simultaneously from SSMI.

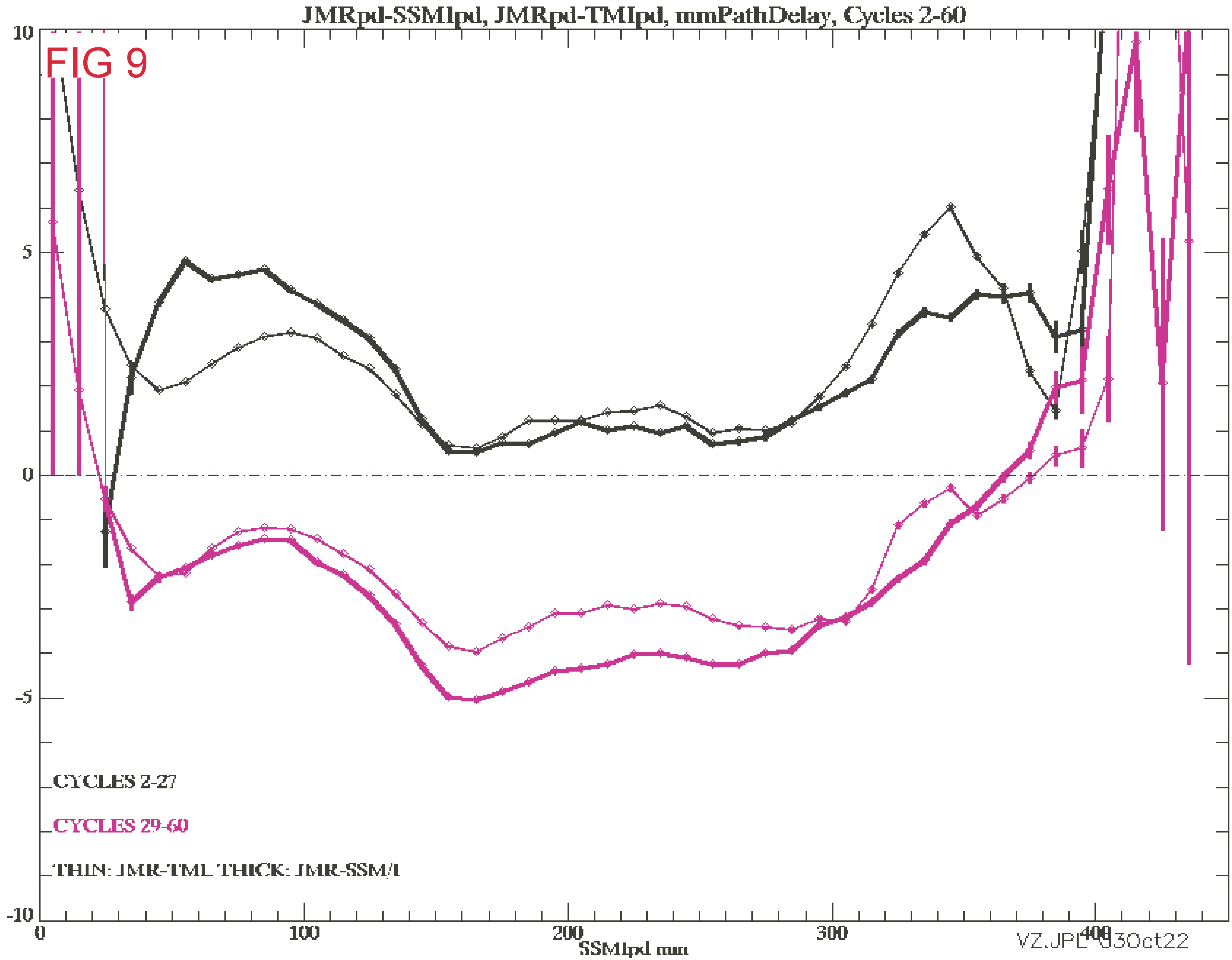
It is hard to ascribe them to either JMR or the SSMI (or TMI), but the differences do not vary in time.

They will become an issue when combining data from two different altimetris sats.



JMR-SSMI PD (mm). Dtime<0.0hr
JMR CYC: 30to61 minus 02to28
FIG 8
-9
0
9
JPL-YZ2003Nov10

FIG 9


JMRpd-SSMIpd, JMRpd-TMIpd, mmPathDelay, Cycles 2-60
10
5
0
-5
-10
0
100
200
300
400
SSMIpd mm
CYCLES 2-27
CYCLES 29-60
THIN: JMR-TMI, THICK: JMR-SSM/I
VZ.JPL 03Oct22

SCALE DEPENDENCE IN JMR-SSM/I PD
CYCLES 2-27 vs 30-60

Figures 8 and 9 indicate that the change in JMR before and after cycle 29 do not have a strong scale or geographic dependence.

This is excellent news, as the sea surface height computed for many studies might otherwise suffer strong regional alterations. The notable exception are studies of global sea level change which are clearly affected, in the absence of a tide-gage calibration.

CONCLUDING REMARKS (1)

• SSM/I and TMI, as processed by Wentz et al, have proven a remarkably stable benchmark for TMR and JMR, despite the fact that many SSM/I instruments have been involved over the past 10+ years.

• Matches of JMR-SSMI, JMR-TMI within 1 hr suffer one drawback: uneven coverage in both geographic and parameter space, with ~ 60 day periodicity.

• ECMWF-derived path delays yield excellent coverage (although an interpolation over 6 hrs in time and coarser space resolution are involved), at the cost of increased noise (standard deviation). Furthermore, the ECMWF data introduce 'jumps' solely associated with changes in the model (CNES now receives routine updates of such changes).

CONCLUDING REMARKS (2)

- JMR, after its post-launch calibrations (to correct for antenna pattern) is clearly within is stated 12 mm uncertainty (see the standard deviation of JMR-SSMI, figure 4)

- JMR-SSMI, JMR-TMI show systematic patterns, with geographic dependence, and little time-variability. While it is not clear whether these are in SSMI or in JMR, if the latter they would affect studies of time variability only across altimetric satellites.

- JMR has experienced two ‘regime changes’ since launch, with changes in path delay > 5 mm, one around 10/2002 (cycle 29), one 300 days later (cycle 60).

- JMR in 2003 display an apparent changes in PD associated with yaw state, even though this was not the case in 2002. The size is ~ 3mm