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IDS recommendations for ITRF2004

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1) Goals of the document

The goal of this document is to provide information for combining long time series of DORIS station coordinates, either in view of the near-to-come ITRF2004 or for DORIS intra-technique combinations for the International DORIS Service (IDS) or for the IERS Combination Pilot Project (IERS-CPP). Following the recommendations for the IERS CPP meeting in Postdam (October 10-11, 2005), this document needed to be finalized before November 15, 2005.

This work is a continuation of the action taken by Martine Feissel-Vernier in June 2005 (http://lareg.ensg.ign.fr/IDS/ITRF2004.html). We completed and finalized it and documented our own synthesis using all available contributions in order to make the document easier to update in the future.

In terms of station selection and station coordinates there are, in fact, three different goals that we think cannot be addressed simultaneously:

1) DORIS stations to be used for the ITRF2004 combination (the most urgent)
2) DORIS core network. This is a sub-network of the above ITRF2004 network to be used to transform each DORIS weekly, monthly solutions or even cumulative solutions (positions and velocities derived over long time periods) into ITRF2004. It is only a subset of the original ITRF2004. Coordinates as well as formal errors and correlations are required but can be derived directly from ITRF2004 solutions as soon as the list of selected stations is known.
3) Coordinates of ALL DORIS stations in ITRF2004 for specific uses, such as Precise Orbit Determination (POD).

In this document, we only address the first two aspects. The third one is less urgent and can only be done later on, as a verification/densification activity exactly in the same way the DPOD2000 network was previously constructed (Willis and Ries 2005).

In particular, we provide here suggestions for Combination Centers (either intra-techniques for IDS combination or inter-techniques for ITRF2004) concerning the following aspects:

- a list of DORIS stations that should be totally removed from any weekly or monthly SINEX solution from all DORIS individual time series (Table 1) before combining them to obtain ITRF2004

- a list of DORIS stations that, during some specific period of time, should be removed from any DORIS individual time series (Table 2)

- a list epochs of discontinuities in DORIS station coordinates time series with proper documentation (Table 3)

- a proposal for a DORIS core network that could be used to base a DORIS realization in ITRF2004. (Table 4)

This action is specifically undertaken for the ITRF2004 Combination Centers, which cannot wait anymore for any DORIS weekly resubmission before estimating ITRF2004. Fortunately, they have all the mathematical tools to manipulate the current SINEX files and to remove stations from weekly solutions in a preprocessing phase of their own combination.

In a perfect world, all these aspects should have been taken care by the DORIS ACs before submitting their solutions, or by the IDS Combination Center when deriving the combined IDS weekly solution. Unfortunately, in practice, there is a lot of information that are not available to the ACs in real time when submitting their weekly solutions on a continuous basis (equipment related problem, station coordinate discontinuities,…). We leave it to the future IDS Analysis Coordinator to decide if the current DORIS SINEX solutions available at NASA/CDDIS should be a posteriori modified or not to accommodate these aspects as well as some others.

This study is based on several recent contributions, in chronological order: a recent analysis of the DORIS network for Precise Orbit Determination (POD) for Jason (Willis and Ries 2005), discussions on IDS Analysis Forum, a proposed IDS contribution to ITRF2004 (Feissel-Vernier 2005), a specific study from IGN/SIMB concerning station quality assessment (Fagard 2005). We provide for each individual table proper references when available. The idea is to make use of all potential information and to make a real synthesis that could be easily reuse in the future by others for regular updates.

As these recommendations will need to be updated regularly in time for regular IDS combinations or for future ITRF solutions, we also describe the criteria that we have used here. Several of them require some level of subjectivity and may be modified in the future. When possible, we also provide some a posteriori validation of our selection in this document. To help future studies of this type that could benefit from this analysis, we also provide as much as possible the sources of the information for future verifications.

Generally, we have been rather selective in our criteria, trying to preserve as much as possible the integrity of the future combinations, starting with ITRF2004, instead of keeping as many DORIS stations as possible. Keeping more stations (especially those with very few observation) could slightly enhance precision of the results but it would endanger the integrity of the combination and require difficult future post-processing validations.

This document will be posted on the IDS Web site as well as the following documents that are submitted in parallel:

- ids_station_breaks.txt = text file: list of epochs of discontinuities in DORIS stations (in ITRF format)

- ids_period_to_delete.txt = text file: list of DORIS observation periods that should be disregarded (in ITRF format)

- ids_core_evolution.mov = movie: evolution in time of the proposed DORIS core network (in one or more movie formats).

This analysis is also mostly based on the analysis of the two DORIS weekly solutions that are currently considered for ITRF2004: IGN/JPL (Willis and Heflin 2004, Willis et al. 2005) and LEGOS/CLS (Soudarin and Crétaux, 2005). However, in the future, inputs from other groups (DORIS Analysis Centers and DORIS intra-technique Combinations Centers, either within IDS or within the IERS/CPP) will be very welcome.

Only DORIS stations that appear in the DORIS data files at the NASA/CDDIS data center are considered here. Therefore, the period of observations used in this document also correspond to DORIS data availability at NASA/CDDIS.

Earlier data before January 1, 1993 are mostly based on single-satellite solutions (SPOT-2) and are much more difficult to validate by DORIS Analysis Groups. Extreme care should be used for these solutions. In view of ITRF2004, we propose to ignore these solutions (anything before January 1, 1993) until a specific investigation is conducted within IDS.

We also only consider the following period of DORIS observation that was selected by the ITRF Product Center (ITRF-PC) for the realization of the ITRF2004: **January 1993 – August 2005**.

If older or more recent data would be used in the future, several criteria would change (duration of observation, new stations, etc.) and a new selection should be done again.

2) DORIS stations that should not be considered for ITRF2004

Stations whose coordinates cannot be modeled as a linear model by interval need to be removed from ITRF2004 (as discussed before, this does not forbid to estimate ITRF2004 in a second step using a densification method). We also want to use similar criteria to those used by other techniques (a significant amount of observation is available to derive a reliable velocity). However, in some specific cases (important collocated sites), it is possible to relax this last criterion as the velocity can be obtained by the data from another technique as well.

Criteria used to reject DORIS stations from submissions to ITRF2004 (corresponding to column “Type” in the following table):

- (1) Insufficient number of observations (2.5 years required). This is the same criterion used for the IGS contribution to ITRF2004, and discussed during the IERS CPP meeting in Potsdam. In the case of DORIS, when two or more stations observe within the same site (e.g. BELB and BEMB), all observations are considered if the DORIS local geodetic survey precision is less than 3 mm (Fagard 2005). If the DORIS local geodetic survey is not available or not precise enough (> 3 mm) then each station is considered independently within the same site.

- (2) antenna instability or non-linear motion due to a specific geophysical event

It must be noted that, for other techniques, the first criterion is also not a strict one and that some stations not fulfilling this criterion could still be included for specific reasons in ITRF2004 as well.

Acronym	Active station	DOMES	Data span (years)	Type	Source	Comment
AJAB	n	10077S002	0.10	(1)	(A)	Insufficient data span
AMSB	n	91401S002	2.35	(2)	(ABCD)	Antenna movement
ARLA	n	33710S001	0.00	(1)	(A)	Observing before 1993.0
CARB	n	41710S001	0.65	(1)	(A)	Insufficient data span
FLOA	n	31901S001	0.46	(1)		Insufficient data span
GAVB	n	12618S001	0.50	(1)		Insufficient data span
HVOA	n	40476S001	0.50	(1)	(A)	Insufficient data span
IQUB	n	41708S001	0.79	(1)		Insufficient data span
KRUA	n	97301S005	0.00	(1)	(A)	Observing before 1993.0
LIFB	n	92722S001	0.96	(1)		Insufficient data span
MALB	Y	22901S002	0.31	(1)		Insufficient data span
MIAB	Y	49914S003	0.48	(1)		Insufficient data span
OTTA	n	40102S009	3.91			
OTTB	n	40102S011	2.50	(1)		Insufficient data span
OTT2	n	40102S007	0.48	(2)	(ABD)	Antenna movement
PASB	n	12339S001	0.29	(1)	(A)	Insufficient data span
RICA	n	40499S015	0.00	(1)	(A)	Observing before 1993.0
SCRB	Y	42005S001	0.38	(1)		Insufficient data span
SIGA	n	30607S001	0.00	(1)	(A)	Observing before 1993.0
SOCA	n	40503S002	0.00	(1)	(A)	Observing before 1993.0
TANB	n	92802S001	0.92	(1)		Insufficient data span
TROA	n	10302S010	0.00	(1)	(A)	Observing before 1993.0
WAIA	n	40475S001	0.52	(1)	(A)	Insufficient data span

Table 1: List of DORIS stations that should not be used at all in any time series

(A) Willis and Ries, 2004
(B) DORIS Mails
(C) IDS Analysis Forum

(D) Feissel-Vernier, et al. 2005

In this table, column 2 indicates if the DORIS station is still observing (Y) or not (n). It can be seen that a large majority of these stations are old station that are not used currently for Precise Orbit Determination and that will not generate new measurements in the future.

In Table 1, the data span is computed from the first epoch of the first beacon in the site to the last epoch of the last beacon (within the 1993.0 – 2005.6 period). It must be noted that the number of observed weeks can be significantly less when the DORIS observation is not continuous (eg. BELB, BEMB). We don't take this problem in consideration here because we assume that a long time span of observation (even discontinuous) is sufficient to compute a reliable velocity.

Some stations have 2 acronyms but represent the same antenna point. This is the case of the Master Beacons. We only consider here in all tables the acronyms corresponding to the first occupation (ie. KRVB = KRUB, TLIA = TLHA, HBLB = HBKB).

For the following stations, even if these stations did not have sufficient observation data, they were kept for ITRF2004 as they correspond to important collocated sites in ITRF2004: JIUB (1.48 yr), BELB (1.48 yr), BEMB (1.48 yr).

We also did not reject station GOLA in this Table, because even if the DORIS-DORIS geodetic local tie (GOLA-GOMB vector) does not appear in the file provided by IGN/SIMB and available at NASA/CDDIS, this information exists. The estimated precision of this geodetic local tie is only 2 cm. This probably explains why it does not appear in the local tie file.

We did not reject station HUAA (1.63 yr) because it could provide an important collocation with an SLR (Satellite Laser Ranging) site.

We did not reject station CROB (1.61 yr) because all other criteria (station coordinate stability, POD residuals) show that it is an excellent station.

We also choose to delete all data from the Ottawa station (station on a 23-storey building, problems with antenna fall due to snow,…).

As only 2 DORIS weekly solutions are considered for ITRF2004, we suggest that the Combination Groups do a preprocessing of the SINEX files to systematically reject stations that only appear in one of the two solutions. Otherwise, this could potentially endanger the integrity of the results. In the future, we also suggest that the IDS Combination Center uses the same strategy (use only stations that appear at least in two different SINEX solutions) before submitting an IDS combined weekly or monthly solutions.

3) Period of specific DORIS observations that should not be used for ITRF2004

We are trying to exclude non-linear motions from DORIS stations

Criteria used:

(1) Antenna movement
(2) Earthquake post-seismic relaxation
(3) Unknown cause
(4) Incomplete stabilization of the newly installed oscillator suspected
(5) Equipment problem
(6) Nonlinear motion related volcano subsidence

Acronym	Active Station	DOMES	Source	Start	End	Comment
AMSA	n	91401S001	(A)	01-JAN-1996	21-APR-1997	(1)
AREA	n	42202S005	(A)	23-JUN-2001	20-NOV-2001	(2)
ASDB	Y	30602S004	(A)	21-JAN-2002	13-APR-2002	(3)
CACB	n	41609S001	(E)	01-JAN-1993	06-NOV-1993	(3)
GOMB	Y	40405S037	(A)	05-JUN-2004	16-JUN-2004	(4)
HELB	Y	30606S003	(B)(A)	01-FEB-2000	31-JUL-2002	(1)
KRAB	Y	12349S001		31-JUL-2005	31-AUG-2005	(3)
MANB	Y	22006S002	(A)	14-JUL-2004	26-JAN-2005	(5)
MARB	n	30313S002	(A)	01-JUL-2004	15-AUG-2004	(1)
MORB	Y	51001S002	(A)	05-FEB-2004	21-AUG-2004	(5)
MSOB	n	50119S002		01-NOV-1998	06-MAR-1999	(3)
SODA	n	40503S003	(A)	01-JAN-1990	01-JAN-1996	(6)
SYOB	n	66006S001	(A)	27-APR-1998	30-MAY-1999	(5)

Table 2: List of stations that should not be used during a specific period

(A) Willis and Ries, 2004
(B) DORIS Mails
(C) IDS Analysis Forum
(D) Feissel-Vernier, 2005
(E) Ries, personal communication (I'm not sure I should get the 'blame' or 'credit' We must all see the problem at the start of the data. I'd try to ascribe the events with no reference to a specific analysis, such as IGND02, rather than something as vague as a personal communication.

In this table, column 2 indicates if the DORIS station is still observing (Y) or not (n).

It can be seen that still a large number of problems are not totally explained.

A few stations were also consider in this list but finally were not selected because we think there is not enough evidence to remove these data. Usually they correspond to specific periods for which the station coordinates are slightly worse, most of time because of data availability. However, we also give here the list of such stations that could be reconsidered in a future document: KOKA (from January to June 1993), KOLB (December 2003 to September 2004), MANB (February 2003 to December 2003), TRIB (February 2002 to July 2004)

For station KRAB, the problem does not stop after August 31, 2005 but continues after that date.

For station CACB, the very early data seem to provide slightly different in height that could alter the long-term velocity determination (Willis and Ries, 2005). The reason is still unknown.

We propose to remove all DORIS solutions before 1993. Presently, this is not a problem as none of the two groups (LEGOS/CLS and IGN/JPL) have submitted any weekly solutions for ITRF2004 before this date. In the future, it is expected that some groups will analyze these older data. However, there are presently very few DORIS data available at NASA/CDDIS before 1993: 3 months in 1990, 5 months in 1992. The large data gaps will make it very difficult to validate these future results in an efficient way.

4) Discontinuities in DORIS station coordinates

All discontinuities detected in either of the two DORIS series appear in this following table, whether the detection was by the Analysis Center or by somebody else.

When the discontinuity is detected as significant by the 2 groups, who also agree on the epoch of discontinuity, the discontinuity is considered as detectable. See annex 1 for details.

Otherwise, it is considered as "not detectable". Even in this case, it is suggested that the Combination Centers try to estimate a discontinuity at this specific epoch. If, after the computation, the estimated vector (before and after the break) is compatible with a zero-hypothesis (no movement detected within the formal error), it is suggested to fix the discontinuity to zero and do a second combination.

Acronym	Active Station	DOMES	Source	Epoch	Type	Detectable	
AREA	n	42202S005	(ADE)	23-JUN-2001	V	Y	(1)
COLA	n	23501S001	(AD)	16-NOV-1994	P	Y	(1)
COLA	n	23501S001	(D)	01-JUL-2001	P	N	(2)
DIOA	Y	12602S011	(ADE)	01-APR-1995	P	Y	(2)
EVEB	Y	21501S001	(D)	01-JAN-2003	P	N	(2)
FAIA	n	40408S004	(DE)	01-JAN-1996	P	Y	(2)
FAIB	Y	40408S005	(A)	03-NOV-2002	P	Y	(1)
KESB	Y	91201S004	(D)	01-JUL-2004	P	Y	(2)
KRAB	n	12349S001	(AD)	01-JAN-1999	P	N	(1)
MANB	Y	22006S002	(BE)	01-JAN-2005	P	Y	(3)
MANB	Y	22006S002	(B)	01-JUN-2005	P	N	(3)
MARB	n	30313S002	(D)	01-JAN-2003	P	Y	(3)
ROTA	n	66007S001	(DE)	20-FEB-1997	V	Y	(2)
SAKA	n	12329S001	(AD)	10-OCT-1994	P	Y	(2)
SAKA	n	12329S001	(D)	26-DEC-1998	P	Y	(2)
SODB	n	40503S004	(AD)	03-OCT-2002	P	Y	(2)
STJB	Y	40101S002	(D)	01-SEP-2002	V	N	(2)
TRIB	Y	30604S002	(A)	31-JUL-2004	P	Y	(2)

Table 3. List of epochs of discontinuities to introduce to compute ITRF2004

(A) Willis and Ries, 2005
(B) DORIS Mails
(C) IDS Analysis Forum
(D) Feissel-Vernier, 2005
(E) Williams and Willis, 2005

(1) Earthquake
(2) Unknown
(3) Antenna displacement

In the table, in column type, P means that the discontinuity is in position (the velocity remain the same after the break), V means that the velocity should be estimated independently after the break (possible change in velocity).

To estimate if the discontinuity is detectable or not, we have used the STCD files at NASA/CDDIS from the 2 groups independently. If the estimate value of the discontinuity is les than 3 times the formal error, at least for one group, we consider that the discontinuity is not detectable. A complete list of results is available in Annex 1 for all these stations. When several beacons have observed within the same DORIS site, all observations are used to compute the velocity and the discontinuity. We used all available STCD files at CDDIS from the 2 solutions. The IGN/JPL contains more data than LEGOS/CLS and time series was expanded after August 2005 too.

We do not consider here the discontinuity in the Goldstone data (GOLA) related to the Hector Mine Earthquake (16 October 1999), as the effect (around 1 mm in all 3 directions in the GPS time series) seems to be below the detection level of the DORIS techniques.

NB: the discontinuities suggested previously are not considered as significant at all and were totally disregarded (see Annex 1 for details)
EVEB 01-JAN-1997
KRAB 01-JAN-2000

5) DORIS core network for ITRF2004

We consider here that it is easier to define the station that should not be part of the DORIS core network (criteria definition) rather than defining criteria for station that are part of the DORIS core network. This will also help maintain such a list in the future.

We also want to have a large core network (typically between 20 to 30 observing stations). Some of criteria that we initially used needed to be loosened. This document only present one possible sets of threshold but different tests were done to refine these criteria.

5.1) DORIS station that should not be part of the DORIS core network

Criteria used:

- insufficient data observation (less than 6 years of observations). In our initial estimation we used 9 yrs of observations and then 7 years of observations. Finally we decided that 6 yrs was presently a better compromise allowing a larger core network without endangering the integrity of the network due to velocity problems

- discontinuity detected in position or velocity (Table 3)

- antenna stability (H. Fagard). After discussing with Herve Fagard, we choose to present this criteria for information in the table (stability mark (MK) < 3), but only for information. No station will be rejected on this criteria alone.

- possibility to delete certain stations that were accessed as "unstable" by Feissel-Vernier et al. 2005. After some tests, we choose the following criteria: stability index > 5, in order to keep a significant amount of DORIS stations in the core network.

Acronym	DOMES	Comment
AJAB	10077S002	(1)
AMSA	91401S001	(6)
AMSB	91401S002	(1)
AREA	42202S005	(2) (6)
ARLA	33710S001	(1)
ARMA	33710S002	(4)
ASDB	30602S004	(6)
BADB	12338S002	(4)
CACB	41609S001	(5) (6)
CARB	41710S001	(1)
CHAB	50207S001	(3)
COLA	23501S001	(2) (4) (6)
DIOA	12602S011	(2) (4) (6)
EVEB	21501S001	(2) (5)
FAIA	40408S004	(2)
FAIB	40408S005	(2)
FLOA	31901S001	(1) (3)
FUTB	92902S001	(3)
GALA	42004S001	(4) (5)
GAVB	12618S001	(1) (3)
GOMB	40405S037	(6)
GREB	40451S176	(3)
HELB	30606S003	(6)
HVOA	40476S001	(1)
IQUB	41708S001	(1) (3)
KESB	91201S004	(2)
KOKA	40424S008	(6)
KOLB	40424S009	(6)
KRAB	12349S001	(2) (4) (6)
KRUA	97301S005	(1)
KRUB	97301S004	(4)

LIFB	92722S001	(1) (3)
MAHB	39801S005	(3)
MALB	22901S002	(1) (3)
MANA	22006S001	(5)
MANB	22006S002	(2) (6)
MARA	30313S001	(5)
MARB	30313S002	(2) (5) (6)
MIAB	49914S003	(1) (3)
MORA	51001S001	(5)
MORB	51001S002	(6)
MSOB	50119S002	(3) (6)
ORRA	50103S201	(3)
ORRB	50103S202	(3)
OTTA	40102S009	(1) (5) (6)
OTT2	40102S007	(1) (6)
OTTB	40102S011	(1) (6)
PASB	12339S001	(1) (3)
PURA	21604S003	(4) (5)
RAQB	92403S001	(5)
RICA	40499S015	(1)
ROTA	66007S001	(2)
SAKA	12329S001	(2) (4) (6)
SALB	39601S002	(3)
SAMB	31903S001	(3)
SANA	41705S007	(5)
SAOB	41705S008	(5)
SCRB	42005S001	(1) (3)
SIGA	30607S001	(1)
SOCA	40503S002	(1)
SODA	40503S003	(5) (6)
SODB	40503S004	(2)
STJB	40101S002	(2) (3)
SYOB	66006S001	(6)
TANB	92802S001	(1) (3)
THUB	43001S005	(3)
TRIB	30604S002	(2) (6)
TROA	10302S010	(1)
WAIA	40475S001	(1)

Table 4. DORIS stations that should be removed from a geodetic core network

(1) That should not be considered at all in DORIS station coordinate time series (see Table 1)
(2) Discontinuity detected (either in position and/or in velocity) (see Table 3)
(3) Insufficient data span (less than 6 years), unless this station has a specific interest for ITRF2004.

(4) site instabilility (H. Fagard), stability mark (MK) < 3 (criterion used for information and not for rejection)
(5) unstable site (M. Feissel-Vernier). We chose the following criteria: stability index > 5.
(6) part of the date needed to be rejected during a significant period of time (Table 2)

It can be seen that usually a station is rejected for several reasons because it fails several types of test and not just one.

5.2) DORIS core network for ITRF2004

We propose to adopt the following core network:

Acronym	DOMES
ADEA	91501S001
ADEB	91501S002
AMTB	91401S003
AREB	42202S006
ARMA	33710S002
BADA	12338S001
BADB	12338S002
BELB	66018S001
BEMB	66018S002
CADB	41609S002
CIBB	23101S001
CICB	23101S002
CROB	91301S001
DAKA	34101S004
DJIA	39901S002
DJIB	39901S003
EASA	41703S008
EASB	41703S009
GOLA	40405S035
GOMA	40405S005
GUAB	50501S001
HBKA	30302S202
HBKB	30302S006
HBLA	30302S005
HELA	30606S002
HEMB	30606S004
HUAA	92202S009
JIUB	21602S005
KERA	91201S002
KERB	91201S003
KITA	12334S004
KITB	12334S005

KIUB	12334S006
KRUB	97301S004
LIBA	32809S002
LIBB	32809S003
META	10503S013
METB	10503S015
MSPB	50119S004
NOUA	92701S001
NOUB	92701S002
PAPB	92201S007
PAQB	92201S008
PDLB	31906S001
PDMB	31906S002
REUA	97401S001
REUB	97401S002
REYA	10202S001
REYB	10202S002
RIDA	40499S016
RIOA	41507S003
RIOB	41507S004
RIPB	41507S005
SAKB	12329S002
SANB	41705S009
SPIA	10317S002
SPIB	10317S004
SPJB	10317S005
SYPB	66006S003
TLHA	10003S003
TLSA	10003S001
TRIA	30604S001
WALA	92901S001
YARA	50107S006
YARB	50107S010
YASB	50107S011
YELA	40127S007
YELB	40127S008

Table 5. Proposed DORIS core network for ITRF2004

This list is derived directly from Table 4 (all stations that do not appear in Table 4 and for which observation is available during the considered January 1993 to August 2005 period appear in Table 5). It includes 68 DORIS stations.

5.3) Validation of DORIS core network for ITRF2004

In order to validate if the criteria used above are not too strict and still define a sufficient number of DORIS stations within the DORIS core network, we have analyzed every three months, how many DORIS stations belong to the DORIS core network and how many stations were rejected. Figure 1 below shows the time evolution of the number of observing core stations.

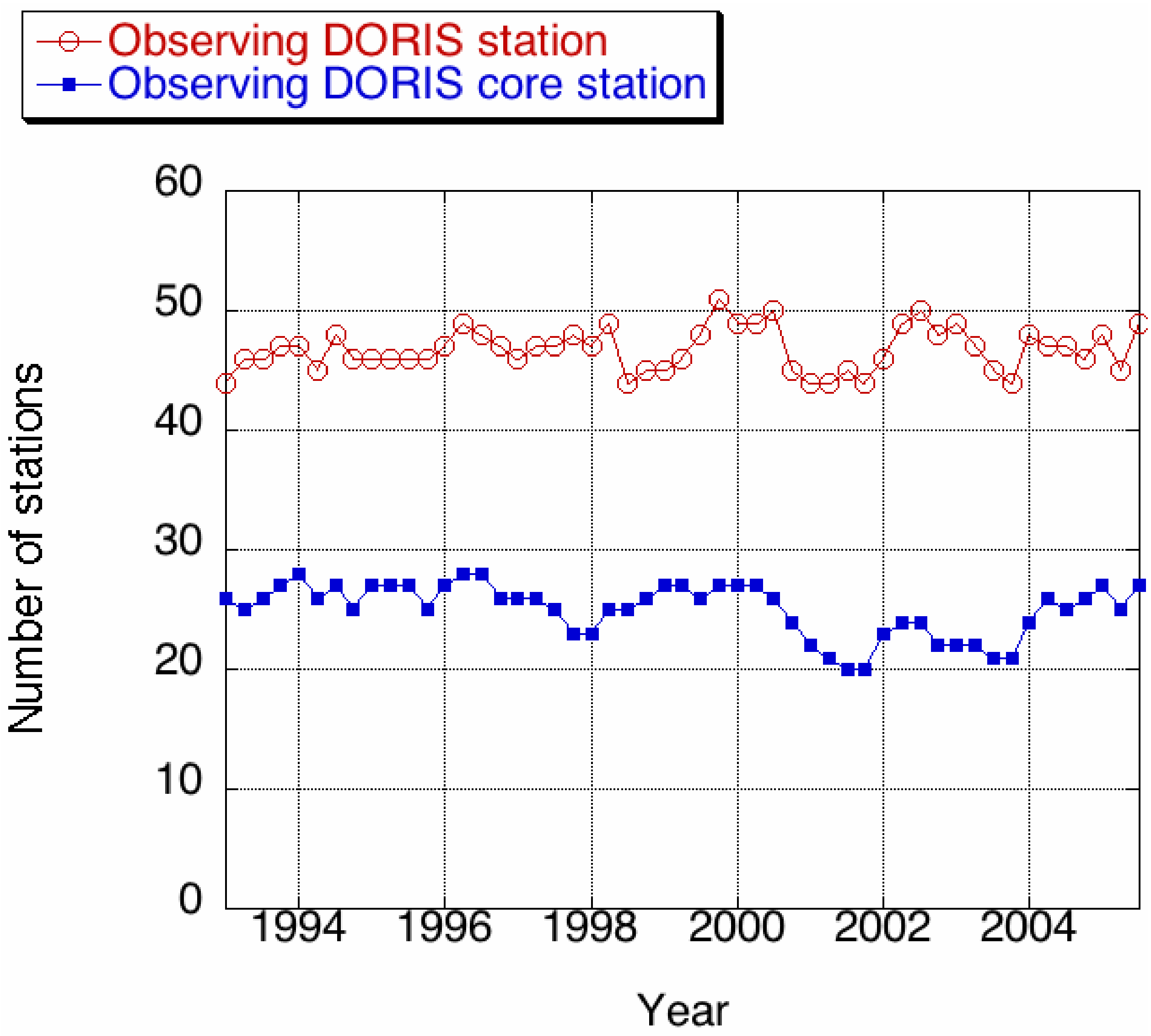
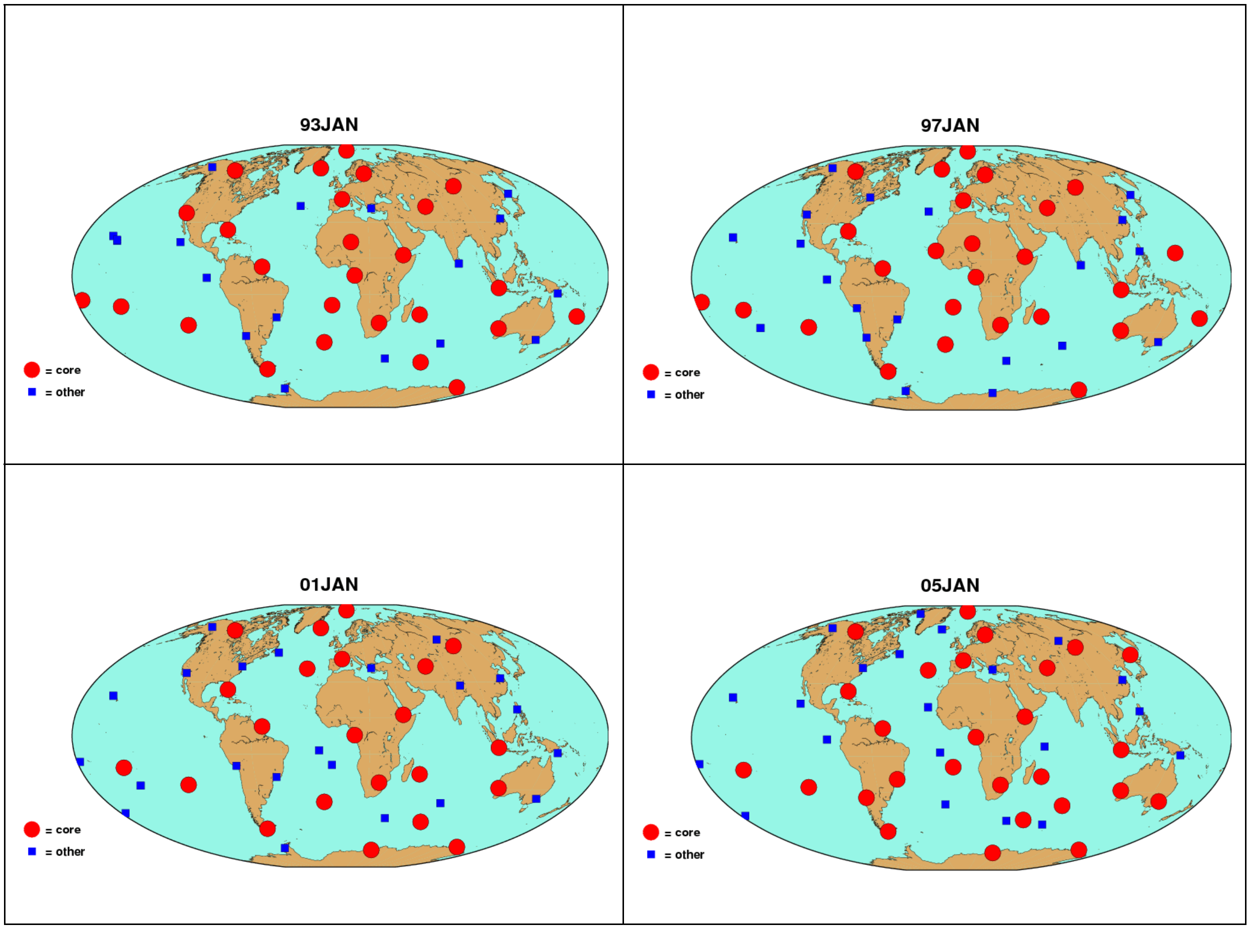


Figure 1. Time evolution of the number of observing DORIS station within DORIS core network

Figure 1 shows that the criteria used for rejection in Table 4 still provide a sufficiently large geodetic DORIS core network.

The plots below show that the geographical distribution is also good. Figures are provided every 2 months, using 1 month of data each time. A movie is also available showing similar monthly plots every 3 months.



This study shows that the selected DORIS core network is sufficiently large to provide continuous and homogeneous observations during the whole considered period (January 1993 to August 2005).

6) Additional comments before using DORIS weekly solution

Combination Centers must also be aware of 2 specific problems related to DORIS data:

- problem detected for DORIS/Jason and related to a large sensitivity of the on-board oscillator to radiations when crossing the South Atlantic Anomaly (Willis et al. 2004). Until a correction model is used (Lemoine et al. in preparation), Jason/DORIS data should not be used in derived geodetic products. If used, without any correction, these data would lead to large velocity errors (several tens of centimeters per year).

- problem detected for DORIS/SPOT4 in the phase center correction provided in the DORIS data files (Willis et al in press). This problem does not affect the LEGOS/LCA solution as this AC was recomputing this correction. This problem does not affect the new IGN/JPL solutions submitted for ITRF2004 (SPOT4 data were not used in 1998 by this AC) but affects previous IGN/JPL submissions. If not corrected properly, the problem will show up in the estimated Z-geocenter (20 cm offset when using 3 satellites) but will less affect station coordinates.

7) Conclusions

We propose here several types of information that could be used by Combination Centers, either for intra-technique combination (IDS combined solution) or for inter-technique combination (ITRF2004). We also propose a selection of stations for a geodetic DORIS core network, that we have tested to verify that the number of stations and their geographical distribution is well suited over the January 1993 to August 2005 period.

In the future, we hope that this work will be reuse to update this information from time to time.

8) References

DORIS Mails, http://listes.cls.fr/wws/arc/dorismail

Fagard site instability, DORIS network quality assessment, excel file.

Feissel-Vernier M (2005) Selection of IDS reference sites in preparation for ITRF2004, July 21, 2005, http://lareg.ensg.ign.fr/IDS/ITRF2004.html

Feissel-Vernier M, Le bail K, Valette (2005) Problem areas in DORIS TRF realization, in preparation for ITRF2004, http://lareg.ensg.ign.fr/IDS/ITRF2004.html

International DORIS Service Analysis Service, http://lareg.ensg.ign.fr/IDS/ITRF2004.html

Lemoine JM et al. (in preparation) Correction model for the SAA effect on Jason/DORIS data, in DORIS Special Issue, *J Geod*

Soudarin L and Crétaux JF (in preparation), Crustal motion observations from 12 years of DORIS measurements , in DORIS Special Issue, *J Geod*

Williams SDP, Willis P (submitted) Noise in DORIS coordinate time series, in DORIS Special Issue, *J Geod*

Willis P, Heflin M (2004) External validation of the GRACE GGM01C gravity field using GPS and DORIS positioning results. *Geophys Res Lett* 31(13):L13616

Willis P, Ries JC (2005) Defining a DORIS core network for Jason-1 precise orbit determination based on ITRF2000, Methods and realization. *J Geod* 79(6-7):370-378

Willis P, Haines B, Berthias JP, Sengenes P, Le Mouel JL (2004) Behavior of the DORIS/Jason oscillator over the South Atlantic Anomaly. *CR Geoscience* 336(9):839-846

Willis P, Boucher C, Fagard H, Altamimi Z (2005a) Geodetic applications of the DORIS system at the French Institut Geographique National. *CR Geoscience* 337(7):653-662

Willis P, J.P. Berthias, Y.E. Bar-Sever (in press) Systematic errors in the Z-geocenter derived using satellite tracking data, A case study from SPOT-4 DORIS data in 1998, *J Geod*

Annex 1

Estimated DORIS discontinuities

In a first test, we have built a list of all possible discontinuities in DORIS station coordinates by using all available sources (see list of references).

In a second step, we have used the suggested epoch of discontinuities (taken for granted) as well as the weekly IGN/JPL STCD files and the monthly LEGOS/CLS STCD files posted at NASA/CDDIS to estimate discontinuities on a station-by-station basis. STCD files (STation Coordinate Differences) were downloaded at NASA/CDDIS on November 4, 2005. At that time, the following solutions were available:

- Weekly files for IGN (ign03wd01), last week is September 14, 2005
- Monthly files for LCA (lca05md01), last month is January 2005

For each station, we estimate the discontinuity independently from the 2 series to verify that they both provide consistent results. For each station, and for each time series, we estimated simultaneously 3 offsets (latitude, longitude and height) using as data weight the formal errors provided in the STCD files, as well as an unknown a priori offset (station position) and drift (station velocity). The chi-square estimate at the end is used to re-weight the a posteriori formal errors, assuming that the a priori formal errors are given with an unknown coefficient. Our formal errors are then considered to be realistic, even if the formal errors in the STCD files are usually too optimistic.

When several discontinuities appear for the same station, all offsets are estimated in the same run using all available data.

Antenna changes are considered as discontinuities. For example, in the case of BELB-BEMB site, all BELB and BEMB data would be considered, estimating 2 unknown for position (plus eventually other discontinuities) and 1 unknown for the velocity (assuming that all stations in the same site have the same velocity).

Based on the following tables, we consider the following categories:

- A = discontinuity detected by the 2 groups (val > 3 for bith) → goes in table 3 in category “detectable”
- B = discontinuity not detected by any of the 2 groups (val < 3 for both) -→ we keep them in the annex to show that we considered them but we don’t put them in Table 2
- C = discontinuity detected by 1 group as significant but not confirmed by the other one (val > 3 for one AC but val < 3 for the other one) -→ we put them in Table 3 in category “non detectable” (we suggest that combination groups estimate these discontinuity but test their significance)

Point	Epoch	IGN North (mm)	IGN East (mm)	IGN Vert (mm)	LCA North (mm)	LCA East (mm)	LCA Vert (mm)	Val IGN	Val LCA
COLA	16-NOV-1994	-57.8 ± 4.3	48.0 ± 5.1	5.8 ± 3.8	-46.6 ± 3.2	27.5 ± 8.2	2.2 ± 5.1	13.4	14.6
COLA	01-JUL-2001	-2.9 ± 5.3	-29.4 ± 6.4	11.7 ± 4.6	-4.0 ± 3.8	-26.2 ± 9.1	4.4 ± 5.7	4.6	2.9
DIOA	01-APR-1995	-5.0 ±4.3	18.3 ±7.5	-17.9 ± 5.2	-0.1 ± 4.0	-65.3 ± 7.4	23.9 ± 6.1	3.4	8.9
EVEB	01-JAN-1997	0.9 ± 4.9	-14.3 ± 8.7	3.1 ± 5.3	-4.9 ± 3.8	20.8 ± 10.3	14.1 ± 5.6	1.6	2.5
EVEB	01-JAN-2003	-4.1 ± 4.6	-2.8 ± 8.0	4.2 ± 4.8	-5.8 ± 3.4	56.9 ± 8.8	5.5 ± 4.8	0.9	6.5
FAIA	01-JAN-1996	-14.7 ± 3.4	10.2 ± 3.1	1.0 ± 3.1	16.6 ± 4.6	-2.3 ± 3.3	-14.1 ± 5.1	4.3	3.6
FAIB	03-NOV-2002	-65.7 ± 2.6	39.6 ± 2.6	13.0 ± 2.4	-38.9 ± 3.7	21.3 ± 2.7	14.3 ± 4.1	25.3	10.5
KESB	01-JUL-2004	11.4 ± 4.1	22.3 ± 5.4	1.9 ± 3.4	18.1 ± 3.8	40.7 ± 6.5	-23.8 ± 4.7	4.1	6.3
KRAB	01-JAN-1999	9.4 ± 8.4	-23.8 ± 8.2	5.8 ± 6.2	(2)	(2)	(2)	2.9	N/A
KRAB	01-JAN-2000	11.7 ± 6.2	-1.7 ± 5.2	-3.1 ± 4.4	3.1 ± 6.2	-8.3 ± 5.5	-1.0 ± 5.8	1.9	1.5
MAN B	01-JAN-2005	63.2 ± 6.5	16.7 ± 12.5	13.6 ±7.8	(3)	(3)	(3)	9.7	N/A
MAN B	01-JUN-2005	-5.2 ± 14.7	23.9 ± 26.6	9.5 ± 18.6	(3)	(3)	(3)	0.9	N/A
MAR B	01-JAN-2003	26.0 ± 4.5	-6.9 ± 5.7	4.0 ±3.4	50.9 ± 4.3	-11.7 ± 5.3	4.5 ± 3.9	5.8	11.8
ROTA	20-FEB-1997	-10.6 ± 3.2	-0.5 ± 3.2	-9.3 ± 2.6	-6.2 ± 2.4	-7.7 ± 2.8	-13.1 ± 3.8	3.6	3.5
SAKA	10-OCT-1994	7.4 ± 5.1	33.6 ± 5.5	13.9 ± 4.8	-3.6 ± 4.2	24.2 ± 4.8	-10.3 ± 5.5	6.1	5.0
SAKA	26-DEC-1999	91.0 ± 9.7	-60 ± 10.6	0.4 ± 9.4	32.4 ± 7.5	-27.2 ± 8.9	-15.0 ± 10.1	9.4	4.3
SAKA	25-NOV-2001	(1)	(1)	(1)	(4)	(4)	(4)	N/A	N/A
SODB	03-OCT-2002	-49.5 ± 4.5	67.0 ± 5.2	-6.0 ± 3.4	-92.3 ± 11.3	69.1 ± 9.0	30.6 ± 9.8	12.9	8.2
STJB	01-SEP-2002	6.6 ± 3.3	1.5 ± 4.1	-16.8 ± 3.5	-3.6 ± 5.6	8.6 ± 5.1	-1.2 ± 5.5	4.8	1.7
TRIB	31-JUL-2004	-58.0 ± 2.7	-19.4 ± 3.6	-35.3 ± 2.5	-42.5 ± 12.8	0.2 ± 5.3	-21.0 ± 3.5	21.5	6.0

Additional comments:

(1) No data in IGN solution between 10-OCT-1994 and 26-DEC-1999 for SAKA.
(2) No data in LCA solution before May 1999 KRAB
(3) No data in LCA solution after July 2004 for MANB
(4) No data in LCA solution between December 1998 and March 2002 for SAKA