

Adaptive Mapping Functions (AMF):

Gegout P., Biancale R., Soudarin L., Adaptive Mapping functions to the Azimuthal Anisotropy of the neutral-Atmosphere, Journal of Geodesy, Volume 85, Number 10, 661-677, 2011. <http://dx.doi.org/10.1007/s00190-011-0474-y>

Camille Desjardins, “Modélisation de la propagation troposphérique des signaux de systèmes de positionnement par satellites: un tour d’Horizon, Thèse UPS 2014. <https://www.theses.fr/188170685> <http://thesesups.ups-tlse.fr/2633/>

ECMWF / Copernicus Reanalysis (ERA5):

Period: 1979 – 2019 update to present after a 3 months delay

Data assimilation system: 2016 ECMWF model cycle 41r2

Spatial resolution: 31 km globally, 137 model levels to 1Pa

Output frequency: Hourly

Atelier GRGS 2019 de Géodésie Millimétrique, 9 – 11 septembre, IAS Toulouse, Occitanie
P. GEGOUT – GET CNRS UMR5563 – Propagation:
One decade of hourly Adaptive Mapping Functions
derived from ERA5 for 400 GPS / GALILEO sites

One decade of hourly AMF for 400 GPS / GALILEO sites: IGS (269) / **Regional (31)** Stations:

ABMF	ABPO	ADAX	ADIS	AIRA	AJAC	ALBH	ALGO	ALIC	ALRT	AMC2	ANKR	AREG	AREQ	AREV	ARMI	ARTU	ARUF	ASCG	ASPA
AUCK	AUT0	BACA	BADG	BAKE	BARH	BEL0	BIK0	BJCO	BJFS	BJNM	BLGU	BOGI	BOGT	BOR1	BRAZ	BREW	BRFT	BRMU	BRST
BRUN	BRUX	BSHM	BUCU	BZRG	CAGZ	CAPA	CAS1	CAST	CAZE	CCJ2	CEBR	CEDU	CHAN	CHER	CHOF	CHPG	CHPI	CHTI	CHUM
CHUR	CIT1	CKIS	CLAR	CMUM	CNMR	COCO	CONZ	COYQ	CPNM	CPVG	CRAL	CRA0	CR01	CUT0	CZTG	DAE2	DAEJ	DARW	DAV1
DGAR	DGAV	DJIG	DLF1	DRAG	DRA0	DUB0	DUBR	DUM1	DUND	DYNG	EBRE	EUSM	FAA1	FAIR	FAJP	FALK	FENO	FFMJ	FILF
FJCP	FLIN	FLRS	FTNA	FUNC	GAMB	GAMG	GANP	GIRO	GLPS	GLSV	GMSD	GODE	GODZ	GOL2	GOLD	GOP6	GOP7	GOPE	GRAC
GRAG	GRAS	GRAZ	GUAM	GUA0	GUAT	GUUG	HARB	HERS	HERT	HLFX	HNLC	HNPT	HOB2	HOFN	HOLB	HOLM	HOLP	HRAG	HRA0
HYDE	IISC	INVK	IQAL	IRKJ	IRKM	IRKT	ISPA	JCTW	JFNG	JNAV	JOG2	JOZ2	JOZE	JPLM	JPRE	KARR	KAT1	KELY	KERG
KIR0	KIR8	KIRI	KIRU	KIT3	KITG	KOKB	KOKV	KOUC	KOUG	KOUR	KRGG	KUNM	KZN2	LACA	LAMA	LAUT	LEIJ	LHAZ	LLAG
LMMF	LPAL	LPGS	LROC	M0SE	MAC1	MAJU	MAL2	MANA	MA00	MAR6	MAR7	MARS	MAS1	MAT1	MATE	MATG	MAUI	MAW1	MAYG
MBAR	MCHL	MCIL	MCM4	MD01	MDVJ	MEDI	METG	METS	MGUE	MIRP	MIZU	MKEA	MOBS	MOLA	MONP	MQZG	MR01	MUN_	MYVA
NAIN	NANO	NAUR	NCKU	NICO	NIST	NIUM	NKLG	NLIB	NNOR	NOT1	NOVM	NRC1	NRIL	NRMD	NRMG	NTUS	NURK	NVSK	NYA1
NYA2	NYAL	OBE4	OHI2	OHI3	ONS1	ONSA	ORIN	OUS2	OWMG	PAD0	PALM	PARC	PARD	PASA	PDEL	PEN2	PENC	PERT	PIE1
PIMI	PIMO	PIN1	PNGM	POHN	POL2	POLV	POTS	PRDS	PTGG	PTVL	PUEC	PUIG	QAQ1	QIKI	QUIN	RABT	RAM0	RBAY	RCMN
RECF	REDU	RES0	REUN	REYK	RGDG	RIGA	RI02	ROAP	SABI	SALU	SAMO	SANT	SASS	SAVO	SCH2	SCOR	SCRZ	SCUB	SEYG
SFER	SGOC	SHA0	SIN0	SIN1	SOFI	SOLO	SOUR	SPT0	SPTU	SSIA	STFU	STHL	STJ3	STJ0	STK2	STR1	STR2	SUTH	SUTM
SUWN	SVTL	SYDN	SYOG	TAH1	TASH	TCMS	TEHN	THTG	THTI	THU2	THU3	TID1	TIDB	TITZ	TIXI	TLSE	TLSG	TNML	TOLO
TONG	TOW2	TR01	TSK2	TUVA	TWTF	UCAL	UCLP	UFPR	ULAB	UNB3	UNBD	UNBJ	UNSA	UNX3	URUM	USC1	USN3	USN4	USN8
USN9	USN0	UZHL	VACS	VERG	VESL	VILL	VIS0	VNDP	VOIM	WARK	WARN	WES2	WHC1	WHIT	WILL	WIND	WROC	WSRT	WTZ2
WTZ3	WTZR	WTZZ	WUH2	WUHN	XMIS	YAKT	YAR2	YARR	YEBE	YEL2	YELL	YIBL	YSSK	ZAMB	ZECK	ZIM2	ZIM3	ZIMJ	ZIMM

One decade of hourly Adaptive Mapping Functions
derived from ERA5 for 400 GPS / GALILEO sites

One decade of hourly ERA5 Adaptive Mapping Functions by Horizon on CCA: Key numbers at a glance:
10,000 kSBU 2017 + 10,000 kSBU 2018 + 10,000 kSBU 2019 = 30.000 kSBU = **2 millions core hours** (400 sites)
ECMWF's HPC Cray CCA : 30 nodes x 36 cores = 1,080 cores Run Time = **1,850 hours = 77 days wall time**
ERA5 model levels database : 10 years x 12 months x 500 Gigabytes / month = **60 Terabytes** (one decade)

ERA5 Dataset citable as: Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate. Copernicus Climate Change Service Climate Data Store (CDS), 2017, 2018, 2019. <https://cds.climate.copernicus.eu/cdsapp#!/home>

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- ECMWF Service Desk: European Center for Medium-Range Weather Forecast
- Copernicus: Europe's eyes on Earth (European Union's Earth Observation Program)
- C3S: Copernicus Climate Change Service at ECMWF

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 P. GEGOUT – GET CNRS UMR5563 – Propagation:
 Two decades of hourly Adaptive Mapping Functions
 derived from ERA5 for IGS REPRO3 GPS / GALILEO sites

223 REPRO3 TOP 3 Priority sites: **available (155)** / **collocated renamed (15)** / **missing (49)** / **discarded (3)** sites :

ABMF	ABPO	ADAX	ADIS	AIRA	AJAC	ALBH	ALGO	ALIC	ALRT	AMC2	ANKR	AREG	AREQ	AREV	ARMI	ARTU	ARUF	ASCG	ASPA
AUCK	AUT0	BACA	BADG	BAKE	BARH	BEL0	BIK0	BJCO	BJFS	BJNM	BLGU	BOGI	BOGT	BOR1	BRAZ	BREW	BRFT	BRMU	BRST
BRUN	BRUX	BSHM	BUCU	BZRG	CAGZ	CAPA	CAS1	CAST	CAZE	CCJ2	CEBR	CEDU	CHAN	CHER	CHOF	CHPG	CHPI	CHTI	CHUM
CHUR	CIT1	CKIS	CLAR	CMUM	CNMR	COCO	CONZ	COYQ	CPNM	CPVG	CRAL	CRA0	CRO1	CUT0	CZTG	DAE2	DAEJ	DARW	DAV1
DGAR	DGAV	DJIG	DLF1	DRAG	DRA0	DUB0	DUBR	DUM1	DUND	DYNG	EBRE	EUSM	FAA1	FAIR	FAJP	FALK	FENO	FFMJ	FILF
FJCP	FLIN	FLRS	FTNA	FUNC	GAMB	GAMG	GANP	GIR0	GLPS	GLSV	GMSD	GODE	GODZ	GOL2	GOLD	GOP6	GOP7	GOPE	GRAC
GRAG	GRAS	GRAZ	GUAM	GUA0	GUAT	GUUG	HARB	HERS	HERT	HLFX	HNLC	HNPT	HOB2	HOFN	HOLB	HOLM	HOLP	HRAG	HRA0
HYDE	IISC	INVK	IQAL	IRKJ	IRKM	IRKT	ISPA	JCTW	JFNG	JNAV	JOG2	JOZ2	JOZE	JPLM	JPRE	KARR	KAT1	KELY	KERG
KIR0	KIR8	KIRI	KIRU	KIT3	KITG	KOKB	KOKV	KOUC	KOUG	KOUR	KRGG	KUNM	KZN2	LACA	LAMA	LAUT	LEIJ	LHAZ	LLAG
LMMF	LPAL	LPGS	LROC	M0SE	MAC1	MAJU	MAL2	MANA	MA00	MAR6	MAR7	MARS	MAS1	MAT1	MATE	MATG	MAUI	MAW1	MAYG
MBAR	MCHL	MCIL	MCM4	MD01	MDVJ	MEDI	METG	METS	MGUE	MIRP	MIZU	MKEA	MOBS	MOLA	MONP	MQZG	MR01	MUN_	MYVA
NAIN	NANO	NAUR	NCKU	NICO	NIST	NIUM	NKLG	NLIB	NNOR	NOT1	NOVM	NRC1	NRIL	NRMD	NRMG	NTUS	NURK	NVSK	NYA1
NYA2	NYAL	OBE4	OHI2	OHI3	ONS1	ONSA	ORIN	OUS2	OWMG	PADO	PALM	PARC	PARD	PASA	PDEL	PEN2	PENC	PERT	PIE1
PIMI	PIM0	PIN1	PNGM	POHN	POL2	POLV	POTS	PRDS	PTGG	PTVL	PUEC	PUIG	QAQ1	QIKI	QUIN	RABT	RAMO	RBAY	RCMN
RECF	REDU	RES0	REUN	REYK	RGDG	RIGA	RI02	ROAP	SABI	SALU	SAM0	SANT	SASS	SAVO	SCH2	SCOR	SCRZ	SCUB	SEYG
SFER	SG0C	SHA0	SIN0	SIN1	SOFI	SOLO	SOUR	SPT0	SPTU	SSIA	STFU	STHL	STJ3	STJ0	STK2	STR1	STR2	SUTH	SUTM
SUWN	SVTL	SYDN	SY0G	TAH1	TASH	TCMS	TEHN	THTG	THTI	THU2	THU3	TID1	TIDB	TITZ	TIXI	TLSE	TLSG	TNML	TOLO
TONG	TOW2	TR01	TSK2	TUVA	TWTF	UCAL	UCLP	UFPR	ULAB	UNB3	UNBD	UNBJ	UNSA	UNX3	URUM	USC1	USN3	USN4	USN8
USN9	USN0	UZHL	VACS	VERG	VESL	VILL	VIS0	VNDP	VOIM	WARK	WARN	WES2	WHC1	WHIT	WILL	WIND	WROC	WSRT	WTZ2
WTZ3	WTZR	WTZZ	WUH2	WUHN	XMIS	YAKT	YAR2	YARR	YEBE	YEL2	YELL	YIBL	YSSK	ZAMB	ZECK	ZIM2	ZIM3	ZIMJ	ZIMM
Level 1 :	ASC1	BAHR	BHR4	CHAT	EISL	GALA	GOUG	KWJ1	MALI	MDVO	NAMA	NOUM	OHIG	RI0G	TAEJ	YAR1	(13)	(3)	
Level 2 :	AOML	BAK0	CAGL	CCJM	FORT	KGNI	KOSG	KSMV	KSTU	MADR	MALD	MARN	MRC1						
	OAFA	OWNG	PARK	PTAG	ROTH	SEJN	SEY1	SMST	SOLA	TABL	TAHI	TOUL	TSKB				(1)	(20)	(5)
Level 3 :	AB07	CASA	CIBG	EFBG	GODN	GODS	HOBU	IUC0	KATC	KBRC	KTVL	LAMP	METZ						
	PHLW	PLTC	RCM5	RCM6	SEAT	STJ2	TRIE	TUC2	USUD	WTZA	WVGB	YAR3					(2)	(16)	(7)

Adaptive Mapping Functions for REPRO3: Two decades of hourly AMF's: Dataset extension 2000-2019:

Scenario 1 (REPRO3 220 sites) :

- Decade 201x: 66 kSBU/site x 49 missing sites = 3,230 kSBU
- Decade 200x: 66 kSBU/site x 217 repro3 sites = 14,320 kSBU Total: 17,550 kSBU = 1,140,000 core hours
- ECMWF's HPC Cray CCA : 30 nodes x 36 cores = 1,080 cores 1,050 hours = 44 days wall time

Scenario 2 (optimized based on sites' availability and occupancy):

- Decade 201x: 66 kSBU/site x 40 missing sites = 2,650 kSBU
- Decade 200x: 66 kSBU/site x 154 repro3 sites = 10,150 kSBU Total: 12,800 kSBU = 832,000 core hours
- ECMWF's HPC Cray CCA : 30 nodes x 36 cores = 1,080 cores 770 hours = 32 days wall time
- Saved> 4,700 kSBU

Scenario 3 (availability, occupancy, renames of collocated sites):

- Decade 201x: 66 kSBU/site x 29 missing sites = 1,950 kSBU
- Decade 200x: 66 kSBU/site x 144 repro3 sites = 9,550 kSBU Total: 11,500 kSBU = 750,000 core hours
- ECMWF's HPC Cray CCA : 30 nodes x 36 cores = 1,080 cores 700 hours = 29 days wall time
- Saved> 6,000 kSBU

ERA5 model levels database :

MARS requests size: 20 years x 12 months x 500 Gigabytes / month = 2 decades x 60 Terabytes / decade

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HORIZON.EA.SYSOP : The SYSTEM is OPERational on ECMWF's Cray CCA

Decade 200x of hourly Adaptive Mapping Functions

Status: REPRO3 Sites RE30: 2009 already available for testing
Status: REPRO3 Sites 201x RE30: Production in progress ...
(speed: 1 year/week) until October 31. Cost 10 MSBU.

Decade 201x of hourly Adaptive Mapping Functions

Status: 400 sites available from January 2010 to June 2019
Status: REPRO3 Sites 201x RE31: Production planned
from Nov. 2019 until end of Jan. 2020. Cost 3 MSBU.

Use Adaptive Mapping Functions with the AMFX Module implemented
in GINS 19.1 (since 2014) and GAMIT/GLOBK 10.7 (since 2016).