Supplementary Data for Evidence of Churches Aligned to the Sun on the Patron Saint's Day in Southern Spain after the Twelfth Century

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FIGURE SF1. Location map and orthophotography of Bujalance (Instituto Geográfico Nacional 2016) with indication of the religious architecture studied in this paper: (1) Church of Our Lady of the Assumption; (2) Church of St Francis of Assisi; (3) Hermitage of Jesus Nazarene; and (4) Church of the Hospitaller order of St John of God.

FIGURE SF2. Illustration of the methodology for measuring church orientation, applied to the case of the parish Church of Our Lady of the Assumption, Bujalance. The georeferenced orthophotography from the Spanish IGN allows measuring grid azimuths from the UTM coordinates of two distant points pertaining to the line that follows the roof ridge of the main nave of the church. Positioning error σ_{xy} and the propagated uncertainties are depicted. Grid azimuths are then converted into geodetic azimuths. The process is repeated n times to estimate dispersion.

A.A. Carazo

FIGURE SF3. Church of St Francis of Assisi, Bujalance. It is aligned with the sunset on the patron saint's feast day (4th October) according to the Julian calendar prevailing at the foundation date; see Table 1 in the main text for more information. During sunset on this day, the Sun's rays cross the rose window on the porch and illuminate the image of the saint, in the central wall of the presbytery. The spot of light appears upwardly displaced because after the reconstruction of the church, the new rose window was placed slightly higher than the original rectangular window. Thanks are given to A. A. Carazo, the local artist photographer, for providing this photograph.

TABLE ST1. Orientation measurements for the systematic survey of churches dedicated to Our Lady of the Assumption in southern Spain (Set S1). The survey includes all the churches from Andalusia, Extremadura, and the episcopates from Ciudad Real, Albacete, Cartagena and Orihuela. The sites are depicted in Figure 1 in the main text, and they roughly cover the Muslim domain at middle the twelfth century. Estimated uncertainties (1σ) are below 0.7° for a church-length over 30 m, which are most of the cases.

Location	Longitude ($^\circ$)	Latitude ($^\circ$)	Azimuth A_{ch} ($^\circ$)
El Villar	-6.7386	37.6939	57.4
Zalamea la Real	-6.6606	37.6804	96.1
Bonares	-6.6837	37.3212	57.9
Almonte	-6.5171	37.2626	59.2
Aroche	-6.9539	37.9453	84.2
Aracena	-6.5605	37.8918	45.3
Santa Olalla de Cala	-6.2348	37.9051	54.4
Cádiz	-6.2754	36.5089	66.0
Ceuta. Catedral	-5.3166	35.8876	141.6
Guadalcanal	-5.8186	38.0972	91.0
Lora del Río	-5.5286	37.6527	92.6
Alcalá del Río	-5.9788	37.5171	79.8
Cantillana	-5.8258	37.6053	85.3
Osuna	-5.1007	37.2375	74.2
Mairena del Alcor	-5.7453	37.3731	83.2
Huévar	-6.2766	37.3572	82.9
Albaida del Aljarafe	-6.1663	37.4272	75.2
Espartinas	-6.1247	37.3828	82.5
Gibralgalía	-4.7661	36.7483	64.5
Cómpeta	-3.9750	36.8327	252.6
Colmenar	-4.3367	36.9031	253.1
Málaga	-4.4418	36.7126	347.7
Almogía	-4.5413	36.8246	204.4
Belalcázar	-5.1663	38.5727	100.3
Bujalance	-4.3829	37.8967	75.7
Cabra	-4.4448	37.4692	72.3
Cañete de las Torres	-4.3174	37.8673	78.4
Castro del Río	-4.4813	37.6905	75.9
Córdoba, Cathedral	-4.7793	37.8790	59.9
Dos Torres	-4.8950	38.4456	100.0
El Carpio	-4.4985	37.9404	67.6

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Table ST1 continued

Location	Longitude (°)	Latitude (°)	Azimuth A_{Ch} (°)
Luque	-4.2777	37.5600	336.0
Montemayor	-4.6986	37.6483	89.6
Montilla*	-4.6464	37.5800	202.3
Palma del Río	-5.2857	37.7010	265.8
Pedro Abad	-4.4548	37.9664	70.9
Priego de Córdoba	-4.1915	37.4395	131.2
Santaella	-4.8463	37.5676	53.9
Valenzuela	-4.2194	37.7749	153.8
La Rambla	-4.7405	37.6086	88.6
Carcabuey	-4.2703	37.4444	35.6
Noalejo	-3.6534	37.5289	71.6
La Guardia	-3.6938	37.7449	30.0
Beas de Segura	-2.8870	38.2508	92.3
Hornos de Segura	-2.7201	38.3166	33.9
Villacarrillo	-3.0860	38.1149	48.4
Iznatoraf	-3.0322	38.1577	143.9
Orcera	-2.6589	38.3178	60.4
Siles	-2.5823	38.3867	92.1
Benatae	-2.6509	38.3536	76.4
Rus	-3.4617	38.0473	74.5
Jódar	-3.3529	37.8449	346.9
Donadío	-3.3658	37.9271	212.2
Campillo del Río	-3.6664	37.9596	8.8
Lupión	-3.5464	37.9963	58.9
Bedmar	-3.4132	37.8213	122.6
Garcíez-Bedmar	-3.4571	37.8729	118.9
Martos*	-3.9697	37.7164	35.1
Villargordo	-3.7268	37.9412	65.2
Porcuna	-4.1851	37.8712	89.8
Cathedral of Jaen	-3.7897	37.7650	67.8
Granada. Sacromonte	-3.5769	37.1828	354.9
La Zubia	-3.5849	37.1209	64.5
Cúllar Vega	-3.6716	37.1512	76.8

Continued

Table ST1 continued

Location	Longitude (°)	Latitude (°)	Azimuth A_{ch} (°)
Pedro Ruiz*	-3.7521	37.2160	256.4
La Mamola	-3.2802	36.7461	330.9
Alfacar	-3.5703	37.2368	53.0
Cogollos Vega	-3.5752	37.2737	54.5
Níjar	-2.2057	36.9656	69.3
Bentarique	-2.6189	36.9861	81.7
Huércal Overa	-1.9434	37.3900	270.7
Vicar	-2.6303	36.8057	79.0
Olula del Río	-2.2974	37.3531	24.7
Venta Quemada	-2.4583	37.5818	1.7
Jerez	-6.1383	36.6835	70.2
Arcos de la Frontera	-5.8062	36.7483	109.1
Hinojal	-6.3574	39.7120	105.1
Casas de Don Antonio	-6.2908	39.2366	57.9
Alcuéscar	-6.2293	39.1812	82.0
Valdefuentes	-6.1268	39.2735	166.3
Sierra de Fuentes	-6.2741	39.4373	84.3
Torremocha	-6.1727	39.3459	69.2
Torre de Santa María	-6.1257	39.2823	86.5
Casar de Cáceres	-6.4193	39.5613	70.4
Aliseda	-6.6912	39.4208	65.3
Vegas de Coria	-6.1855	40.3841	72.0
Nuñomoral	-6.2445	40.4091	44.2
Ahigal	-6.1875	40.1901	74.4
Zarza de Granadilla	-6.0471	40.2379	76.2
Casillas de Coria	-6.6366	39.9659	34.3
Montehermoso	-6.3498	40.0887	76.1
Villanueva de la Sierra	-6.4044	40.2001	71.9
Torre de Don Miguel	-6.5772	40.2243	92.8
Robledillo de Gata	-6.4708	40.3219	231.6
Torrecilla de los Ángeles	-6.4198	40.2478	57.9
Pescueza	-6.6461	39.9176	90.5
Valverde del Fresno	-6.8793	40.2242	99.4
Eljas	-6.8467	40.2172	95.6

Continued

Table ST1 continued

Location	Longitude (°)	Latitude (°)	Azimuth A_{ch} (°)
Perales del Puerto	-6.6821	40.1539	86.6
Arroyo de la Luz	-6.5851	39.4841	75.8
Malpartida de Cáceres	-6.5056	39.4455	91.5
Estación Arroyo-Malpartida	-6.5378	39.4663	225.2
Galisteo	-6.2664	39.9768	355.8
Valle de Matamoros	-6.8036	38.3789	71.4
Sagrajas*	-6.9023	38.9215	164.4
Entrín Bajo	-6.7143	38.7192	175.5
La Nava de Santiago	-6.5058	39.0622	75.4
La Garrovilla	-6.4731	38.9204	87.4
Fuente del Arco	-5.8971	38.1517	90.8
Mérida†	-6.3471	38.9166	57.8
Mérida†	-6.3471	38.9166	52.7
Badajoz	-6.9786	38.8946	326.1
Villarreal	-7.2141	38.7259	75.9
Táliga	-7.0161	38.5286	80.8
La Parra	-6.6252	38.5209	74.7
Segura de León	-6.5291	38.1202	75.9
Benquerencia de la Serena	-5.4942	38.6992	64.1
Malpartida de la Serena	-5.6398	38.6745	83.2
Valencia de las Torres	-6.0028	38.4042	81.5
Campanario	-5.6173	38.8633	74.6
Villanueva de la Serena	-5.7996	38.9741	69.0
Calamonte	-6.3871	38.8912	89.4
Bogarra	-2.212	38.5801	98.3
Lezuza	-2.3532	38.949	74.6
Hellín	-1.7032	38.512	357.8
Letur	-2.1008	38.3665	41.9
Yeste	-2.3187	38.3663	76.4
Tobarra	-1.6934	38.5887	100.8
Manzanares	-3.3723	38.9965	76.7
Alcolea de Calatrava	-4.1158	38.9870	78.6
Anchuras	-4.8359	39.4800	132.3
Abenójar	-4.3576	38.8793	245.8

Continued

Table ST1 continued

Location	Longitude (°)	Latitude (°)	Azimuth A_{ch} (°)
Arroba de los Montes	-4.5430	39.1538	101.6
Calzada de Calatrava	-3.7753	38.7040	52.5
Puertollano	-4.1119	38.6861	85.5
Campo de Criptana	-3.1257	39.4057	76.8
Tomelloso	-3.0206	39.1583	60.6
Piedrabuena	-4.1752	39.0358	272.7
Miguelturra	-3.890	38.9650	59.8
Valdepeñas	-3.3845	38.7602	98.5
Puebla del Príncipe	-2.9247	38.5679	74.6
Villarrubia de los Ojos	-3.6076	39.2195	58.9
Villahermosa	-2.8719	38.7505	70.0
Caracuel de Calatrava	-4.0653	38.8445	55.8
Almodóvar del Campo	-4.1794	38.7096	84.1
Socuéllanos	-2.7939	39.2934	67.3
Santa Cruz de Mudela	-3.4675	38.6449	87.6
Viso del Marqués	-3.5625	38.5232	92.1
Albacete*	-1.8598	38.9975	61.2
Mahora	-1.7247	39.213	101.4
Jorquera	-1.5203	39.1741	134.7
Socovos	-1.9843	38.3295	105.3
Férez	-2.0095	38.356	73.2
Almansa	-1.0943	38.8701	311.6
El Moral Entredicho	-2.2102	37.9983	357.3
Moratalla	-1.8931	38.1910	49.8
Molina de Segura	-1.2114	38.0505	78.1
Cieza	-1.4271	38.2368	73.4
Villanueva del Segura	-1.3242	38.1373	356.0
Los Alcázares*	-0.8479	37.7444	320.3
Fuensanta-Lorca	-1.8953	37.7279	341.3
Alcantarilla	-1.2204	37.9682	265.3
Jijona	-0.5078	38.5395	356.4
Santa Pola	-0.5559	38.1933	308.8
Biar	-0.7660	38.6299	144.6

Continued

Table ST2 continued

Location	Longitude (°)	Latitude (°)	Azimuth A_{ch} (°)
Guadalest	-0.1978	38.6773	15.6
La Vila Joiosa	-0.2322	38.5054	95.0
Sax	-0.8171	38.5054	56.0

* Twentieth-century building.

† The church at Mérida has two transects which define different azimuths, and both have been recorded.

TABLE ST2. Orientation measurements for the systematic survey of churches dedicated to St Francis in southern Spain (Set S2). The survey includes all the churches in Spain, separated into two groups: those from (1) Andalusia, Extremadura and the episcopates from Ciudad Real, Albacete, Cartagena and Orihuela (Region S1); and (2) the rest of the country. The sites are depicted in Figure 1 in the main text. Estimated uncertainties are below 0.7° for a church-length over 30 m, which are most of the cases.

Location	Longitude (°)	Latitude (°)	Azimuth A_{ch} (°)
----- (1) Churches in the region defined by Set S1 -----			
Huelva*	-6.9262	37.2579	47.1
San Fernando	-6.1999	36.4619	122.9
Tarifa	-5.60418	36.0127	71.0
Morón de la Frontera	-5.4546	37.1172	342.3
Jubrique	-5.2164	36.5648	242.7
Bujalance	-4.3806	37.8958	78.2
Palma del Río	-5.2799	37.6943	68.6
Bembézar*	-5.2381	37.7950	316.4
Rute	-4.3655	37.3269	89.4
Córdoba	-4.7751	37.8817	74.7
Cabra*	-4.4287	37.4745	84.7
Villacarrillo*	-3.0764	38.1202	57.3
Martos†	-3.9792	37.7219	79.2
Linares	-3.6319	38.0947	78.6
Guadalén*	-3.5068	38.1418	162.2
Escoznar	-3.8459	37.2339	8.9
Lagos	-3.4370	36.7942	346.2
Turre	-1.8936	37.1507	181.5
Aulago	-2.6248	37.1599	229.9
Guadix	-3.1328	37.3000	28.7
El Puerto de Santa María	-6.2332	36.599	206.2

Continued

Table ST2 continued

Arcos de la Frontera	-5.8158	36.754	87.5
San Francisco de Olivenza*	-7.1046	38.7457	151.9
Villanueva de la Serena	-5.7951	38.9731	77.5
Caudete*	-0.9847	38.7105	308.0
Albacete*	-1.8606	38.9889	211.8
Nava de Campaña*	-1.6496	38.4918	344.0
Aigües	-0.3632	38.5004	91.7
Alicante*	-0.5151	38.3484	277.3
La Marina*	-0.6464	38.1444	360.6
El Altet*	-0.5484	38.273	290.5
Elche*	-0.7041	38.2746	159.4
Villena*	-0.8512	38.6312	84.5
Benidorm*	-0.1250	38.5476	64.4
Murcia *	-1.1304	37.9932	360.8
Caravaca de la Cruz*	-1.8623	38.1124	104.5
------(2) Churches in the rest of the country-----			
Barbastro	0.1275	42.0379	94.3
Barcelona*	2.1982	41.3959	135.2
Badalona*	2.2393	41.4577	336.1
Bilbao	-2.9330	43.2575	140.8
Bermeo	-2.7248	43.4187	98.0
Las Palmas GC	-17.7616	28.6871	88.2
Fuenlabrada*	-3.8061	40.2897	107.7
Sangarrén	-0.4316	42.0176	150.2
Madrid*	-3.6615	40.3931	124.6
Maó	4.2609	39.8913	298.3
Ciudadella	3.8371	40.0004	153.5
Soria	-2.4715	41.7631	83.7
Millanes de la Mata	-5.5805	39.8487	0.0
Salamanca*	-5.6463	40.9656	156.5
Hondarribia	-1.7985	43.3524	295.5
Santander*	-3.8112	43.4630	264.1
A Coruña*	-8.4140	43.3641	186.5
Tilos*	-8.5416	42.8425	110.1

Continued

Table ST1 continued

Castellón de la Plana*	-0.0426	39.9798	120.5
villarreal	-0.1037	39.9359	225.3
Lumpiaque	-1.2999	41.6310	217.8
Tarzona	-1.7237	41.9040	49.7
Tarragona	1.2534	41.1169	214.5
Reus	1.1083	41.1521	134.8
Santa Cruz de Tenerife	-16.2493	28.4679	276.7
Sabadell*	2.1153	41.5301	248.6
Jesús*	0.5108	40.8251	207.0
Vigo	-8.7290	42.2358	292.9
Balones	-0.3426	38.7369	47.7
Margarida	-0.2988	38.7881	20.8
Llíria	-0.5994	39.6284	37.1
Oliva*	-0.1157	38.9160	224.4
La Granja de la Costera	-0.5574	38.9961	200.6
Vitoria-Gasteiz*	-2.6690	42.8558	134.5
Zaragoza*	-0.8855	41.6324	281.3
Bardenas*	-1.2000	42.1795	272.4

* Twentieth-century building.

† Azimuth measured for the reconstructed building.

Reference

Instituto Geográfico Nacional, 2016. Iberpix viewer [online]. Accessed March 2016, <http://www.ign.es/iberpix2/visor/#>