

# Evaluating different methods for monthly glacier mass balance interpolation at the example of a tropical glacier

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## Setting

**Conejeras glacier** is located in the Andes of Colombia, in the Cordillera Central, ca. 140 km west of Bogotá. It is on the western side of Nevado Santa Isabel, the middle one of three glacierized volcanoes.

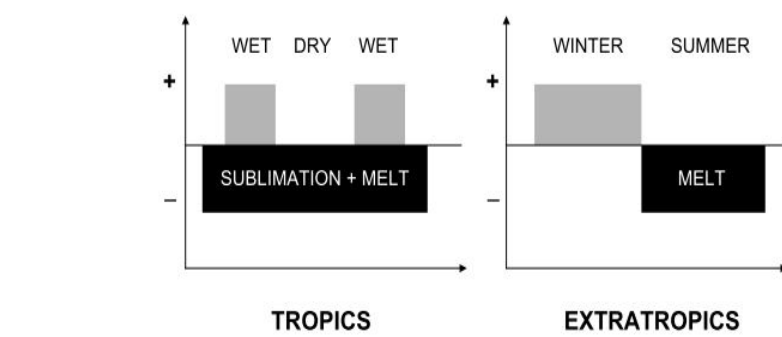
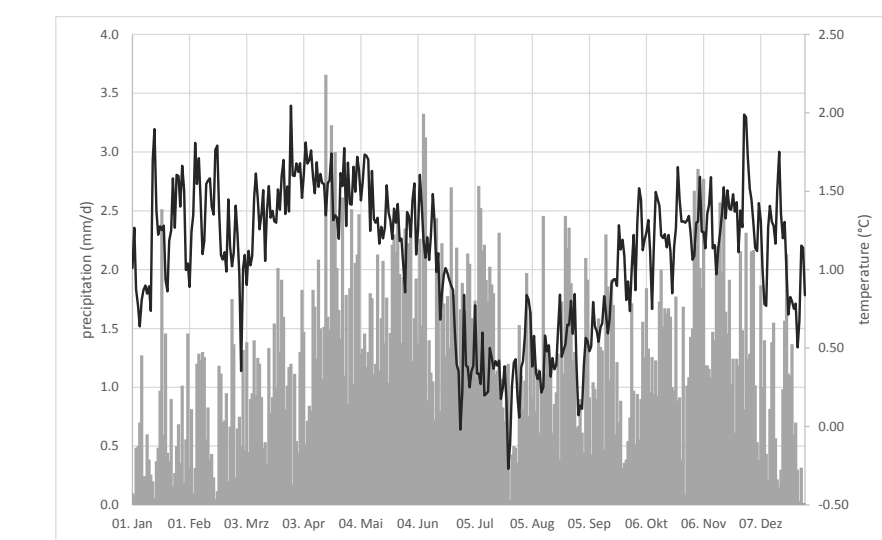


Figure 5: Accumulation (gray) and ablation (black, with dominant components) on mountain glaciers due to atmospheric forcing in the tropics (succession of wet and dry seasons) and extratropics (succession of temperature seasons), modified from Kaser et al. (1996); Mölg, T. (2009)

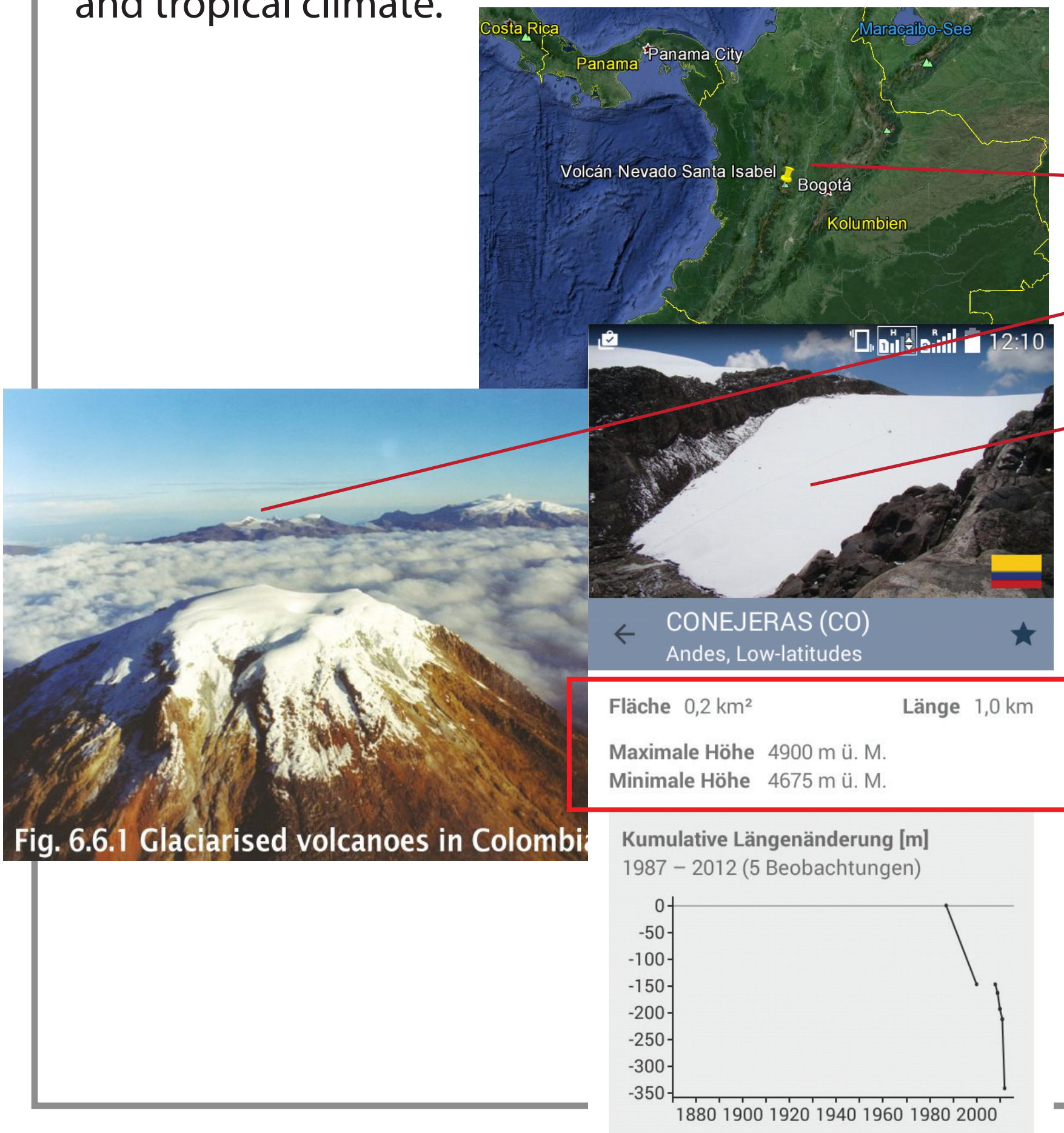


The figures show the basic climatic difference between tropics and extratropics.

The second figure shows that there is no dry period on Conejeras and the seasonal temperature cycle is ~1.5°.

## Programme

A mass balance programme was started in 2006. Because a clear separation in accumulation and ablation season is not possible in the Inner Tropics, a monthly measurement interval was chosen, to better understand the relations of mass balance and tropical climate.



## Mass Balance Programme:

- 14 stakes
- February 2006
- Monthly measurements

## Aim

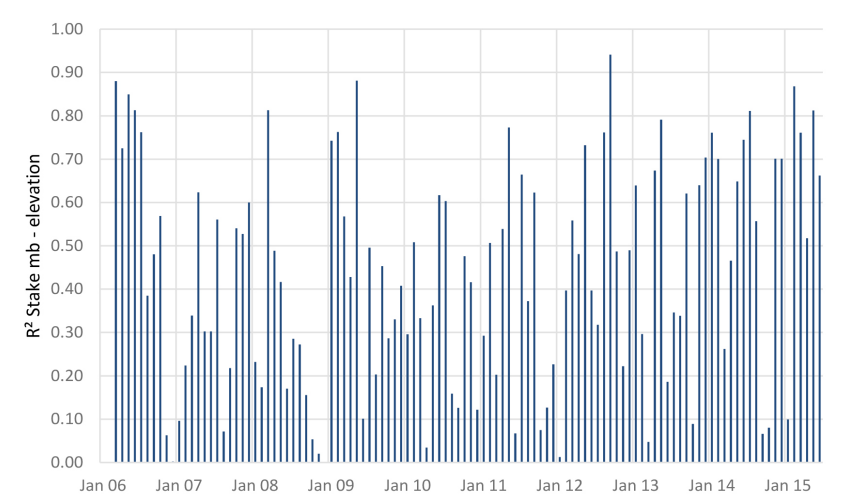
Ten years of measurements - reported balances partly inconsistent - high quality DEM available  
For these reasons a reanalysis of the whole time series has been done.

## Mass Balance Reanalysis

- Snow density
- Elevation information  
30 m elevation bins
- Measurement date correction
- Ablation stake outliers
- Interpolation method



Reanalysis shows:  
Weak relation mass balance - elevation



## Interpolation Methods

Pre-Conditions:

- High stake density
- Even distribution
- Good coverage

Potential for use of different methods

“Manual” Methods:

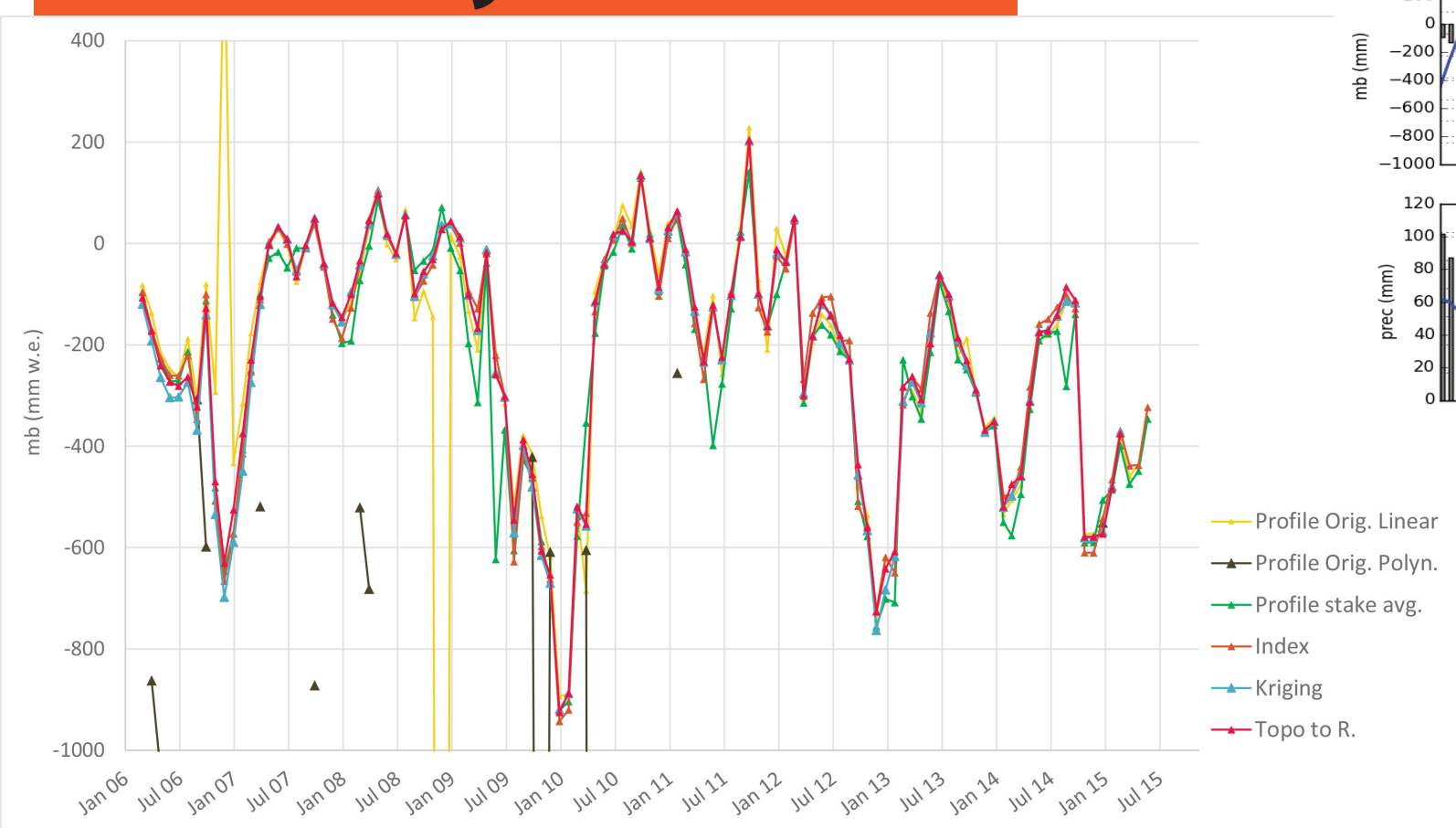
- Profile Method
- Original
- Stake Averaged
- Contour Line Method
- Index Method

Van Beusekom et al. 2010

GIS Methods:

- Kriging
- Topo to Raster

## Monthly results



A comparison of the results of the different interpolation methods (graph + table). Index method and GIS methods are most stable and reliable.

	Profile Orig. Linear	Profile Orig. Polyn.	Profile stake avg.	Index	Kriging	Topo to R.
SUM	-2859	-2854	-2862	-2907	-2790	-2546
May 06	-82	-82	-95	-82	-95	-100
Jun 06	-137	-137	-130	-137	-130	-125
Jul 06	-215	-215	-208	-215	-208	-203
Aug 06	-248	-248	-232	-248	-232	-227
Sep 06	-263	-263	-247	-263	-247	-242
Oct 06	-268	-268	-252	-268	-252	-247
Nov 06	-272	-272	-256	-272	-256	-251
Dec 06	-277	-277	-261	-277	-261	-256
Jan 07	-283	-283	-267	-283	-267	-262
Feb 07	-288	-288	-272	-288	-272	-267
Mar 07	-293	-293	-277	-293	-277	-272
Apr 07	-298	-298	-282	-298	-282	-277
May 07	-303	-303	-287	-303	-287	-282
Jun 07	-308	-308	-292	-308	-292	-287
Jul 07	-313	-313	-297	-313	-297	-292
Aug 07	-318	-318	-302	-318	-302	-297
Sep 07	-323	-323	-307	-323	-307	-302
Oct 07	-328	-328	-312	-328	-312	-307
Nov 07	-333	-333	-317	-333	-317	-312
Dec 07	-338	-338	-322	-338	-322	-317
Jan 08	-343	-343	-327	-343	-327	-322
Feb 08	-348	-348	-332	-348	-332	-327
Mar 08	-353	-353	-337	-353	-337	-332
Apr 08	-358	-358	-342	-358	-342	-337
May 08	-363	-363	-347	-363	-347	-342
Jun 08	-368	-368	-352	-368	-352	-347
Jul 08	-373	-373	-357	-373	-357	-352
Aug 08	-378	-378	-362	-378	-362	-357
Sep 08	-383	-383	-367	-383	-367	-362
Oct 08	-388	-388	-372	-388	-372	-367
Nov 08	-393	-393	-377	-393	-377	-372
Dec 08	-398	-398	-382	-398	-382	-377
Jan 09	-403	-403	-387	-403	-387	-382
Feb 09	-408	-408	-392	-408	-392	-387
Mar 09	-413	-413	-397	-413	-397	-392
Apr 09	-418	-418	-402	-418	-402	-397
May 09	-423	-423	-407	-423	-407	-402
Jun 09	-428	-428	-412	-428	-412	-407
Jul 09	-433	-433	-417	-433	-417	-412
Aug 09	-438	-438	-422	-438	-422	-417
Sep 09	-443	-443	-427	-443	-427	-422
Oct 09	-448	-448	-432	-448	-432	-427
Nov 09	-453	-453	-437	-453	-437	-432
Dec 09	-458	-458	-442	-458	-442	-437
Jan 10	-463	-463	-447	-463	-447	-442
Feb 10	-468	-468	-452	-468	-452	-447
Mar 10	-473	-473	-457	-473	-457	-452
Apr 10	-478	-478	-462	-478	-462	-457
May 10	-483	-483	-467	-483	-467	-462
Jun 10	-488	-488	-472	-488	-472	-467
Jul 10	-493	-493	-477	-493	-477	-472
Aug 10	-498	-498	-482	-498	-482	-477
Sep 10	-503	-503	-487	-503	-487	-482
Oct 10	-508	-508	-492	-508	-492	-487
Nov 10	-513	-513	-497	-513	-497	-492
Dec 10	-518	-518	-502	-518	-502	-497
Jan 11	-523	-523	-507	-523	-507	-502
Feb 11	-528	-528	-512	-528	-512	-507
Mar 11	-533	-533	-517	-533	-517	-512
Apr 11	-538	-538	-522	-538	-522	-517
May 11	-543	-543	-527	-543	-527	-522
Jun 11	-548	-548	-532	-548	-532	-527
Jul 11	-553	-553	-537	-553	-537	-532
Aug 11	-558	-558	-542	-558	-542	-537
Sep 11	-563	-563	-547	-563	-547	-542
Oct 11	-568	-568	-552	-568	-552	-547
Nov 11	-573	-573	-557	-573	-557	-552
Dec 11	-578	-578	-562	-578	-562	-557
Jan 12	-583	-583	-567	-583	-567	-562
Feb 12	-588	-588	-572	-588	-572	-567
Mar 12	-593	-593	-577	-593	-577	-572
Apr 12	-598	-598	-582	-598	-582	-577
May 12	-603	-603	-587	-603	-587	-582
Jun 12	-608	-608	-592	-608	-592	-587
Jul 12	-613	-613	-597	-613	-597	-592
Aug 12	-618	-618	-602	-618	-602	-597
Sep 12	-623	-623	-607	-623	-607	-602
Oct 12	-628	-628	-612	-628	-612	-607
Nov 12	-633	-633	-617	-633	-617	-612
Dec 12	-638	-638	-622	-638	-622	-617
Jan 13	-643	-643	-627	-643	-627	-622
Feb 13	-648	-648	-632	-648	-632	-627
Mar 13	-653	-653	-637	-653	-637	-632
Apr 13	-658	-658	-642	-658	-642	-637
May 13	-663	-663	-647	-663	-647	-642
Jun 13	-668	-668	-652	-668	-652	-647
Jul 13	-673	-673	-657	-673	-657	-652
Aug 13	-678	-678	-662	-678	-662	-657
Sep 13	-683	-683	-667	-683	-667	-662
Oct 13	-688	-688	-672	-688	-672	-667
Nov 13	-693	-693	-677	-693	-677	-672
Dec 13	-698	-698	-682	-698	-682	-677
Jan 14	-703	-703	-687	-703	-687	-682
Feb 14	-708	-708	-692	-708	-692	-687
Mar 14	-713	-713	-697	-713	-697	-692
Apr 14	-718	-718	-702	-718	-702	-697
May 14	-723	-723	-707	-723	-707	-702
Jun 14	-728	-728	-712	-728	-712	-707
Jul 14	-733	-733	-717	-733	-717	-712
Aug 14	-738	-738	-722	-738	-722	-717
Sep 14	-743	-743	-727	-743	-727	-722
Oct 14	-748	-748	-732	-748	-732	-727
Nov 14	-753	-753	-737	-753	-737	-732
Dec 14	-758	-758	-742	-758	-742	-737
Jan 15	-763	-763	-747	-763	-747	-742
Feb 15	-768	-768	-752	-768	-752	-747
Mar 15	-773	-773	-757	-773	-757	-752
Apr 15	-778	-778	-762	-778	-762	-757
May 15	-783	-783	-767	-783	-767	-762
Jun 15	-788	-788	-772	-788	-772	-767
Jul 15	-793	-793	-777	-793	-777	-772
Aug 15	-798	-798	-782	-798	-782	-777
Sep 15	-803	-803	-787	-803	-787	-782
Oct 15	-808	-808	-792	-808	-792	-787
Nov 15	-813	-813	-797	-813	-797	-792
Dec 15	-818	-818	-802	-818	-802	-797
Jan 16	-823	-823	-807	-823	-807	-802
Feb 16	-828	-828	-812	-828	-812	-807
Mar 16	-833	-833	-817	-833	-817	-812
Apr 16	-838	-838	-822	-838	-822	-817
May 16	-843	-843	-827	-843	-827	-822
Jun 16	-848	-848	-832	-848	-832	-827
Jul 16	-853	-853	-837	-853	-837	-832
Aug 16	-858	-858	-842	-858	-842	-837
Sep 16	-863	-863	-847	-863	-847	-842
Oct 16	-868	-868	-852	-868	-852	-847
Nov 16	-873	-873	-857	-873	-857	-852
Dec 16	-878	-878	-862	-878	-862	-857
Jan 17	-883	-883	-867	-883	-867	-862
Feb 17	-888	-888	-872	-888	-872	-867
Mar 17	-893	-893	-877	-893	-877	-872
Apr 17	-898	-898	-882	-898	-882	-877
May 17	-903	-903	-887	-903	-887	-882
Jun 17	-908	-908	-892	-908	-892	-887
Jul 17	-913	-913	-897	-913	-897	-892
Aug 17	-918	-918	-902	-918	-902	-897
Sep 17	-923	-923	-907	-923	-907	-902
Oct 17	-928	-928	-912	-928	-912	-907
Nov 17	-933	-933	-917	-933	-917	-912
Dec 17	-938	-938	-922	-938	-922	-917
Jan 18	-943	-943	-927	-943	-927	-922
Feb 18	-948	-948	-932	-948	-932	-927
Mar 18	-953	-953	-937	-953	-937	-932
Apr 18	-958	-958	-942	-958	-942	-937
May 18	-963	-963	-947	-963	-947	-942
Jun 18	-968	-968	-952	-968	-952	-947
Jul 18	-973	-973	-957	-973	-957	-952
Aug 18	-978	-978	-962	-978	-962	-957
Sep 18	-983	-983	-967	-983	-967	-962
Oct 18	-988	-988	-972	-988	-972	-967
Nov 18	-993	-993	-977	-993	-977	-972
Dec 18	-998	-998	-982	-998	-982	-977
Jan 19	-1003	-1003	-987	-1003	-987	-982
Feb 19	-1008	-1008	-992	-1008	-992	-987
Mar 19	-1013	-1013	-997	-1013	-997	-992
Apr 19	-1018	-1018	-1002	-1018	-1002	-997
May 19	-1023	-1023	-1007	-1023	-1007	-1002
Jun 19	-1028	-1028	-1012	-1028	-1012	-1007
Jul 19	-1033	-1033	-1017	-1033	-1017	-1012
Aug 19	-1038	-1038	-1022	-1038	-1022	-1017
Sep 19	-1043	-1043	-1027	-1043	-1027	-1022
Oct 19	-1048	-1048	-1032	-1048	-1032	-1027
Nov 19	-1053	-1053	-1037	-1053	-1037	-1032
Dec 19	-1058	-1058	-1042	-1058	-1042	-1037
Jan 20	-1063	-1063	-1047	-1063	-1047	-1042