Source-by-source Commentary on Assimilation of HS Data — (January 2012)

Physiography (S, Zmin, Zmax, Lmax, PClass, Form) is from WGI-XF unless otherwise indicated.

HS0001 Driedger and Kennard 1986

S, $Lmax$ from Table I and $Hbar$ from Table III, except all three from Table II for Dinwoody, Grinnell, Maclure, South Cascade and Whitney. V is $S \times Hbar$, and is not quite the same as the tabulated V. $Zmin$, $Zmax$ and slope all from R. Hock. Date (the year before Kennard's Master's thesis) is conjectural. Track density is the sum of the 23 core glaciers' areas (59.44 km^2) divided by ("about 200" times 50 m), the 50 m being an arbitrary estimate of the representativeness in distance of each point radar measurement. References need to be checked for Dinwoody and South Cascade.

HS0002 Hodge 1979

HS0003 Jacobel 1995

HS0004 Macheret et al. 1988

$Hbar$ calculated from Table 4 of the paper as S/V. IdCode, $Zmin$, $Zmax$, $Lmax$, $PClass$, $Form$ from WGI-XF. V was obtained mainly from longitudinal profiles by helicopter. Track density was therefore estimated as $S/Lmax$, except for two glaciers covered by ground survey whose track density was estimated as $S/(Lmax + nWbar)$, n being the number of cross-profiles given in Table 3 and $Wbar$ (not in WGI-XF) a typical width (600 m for Shumskyj, 400 m for Muravlv).

NB: The basin codes 5A13206 and 5A13207 in WGI-XF are wrong. They should be 5X13206 and 5X13207 respectively.

HS0005 Zhuravlev 1981

Estimates of volume for 57 Svalbard glaciers, based on airborne radio echo sounding and, in four cases, more detailed ground survey; thickness traverses for Austfonna were taken from the seismic surveys of Ekman (1971; HS0015).

Dowdeswell et al. (1984) pointed out that some of the Zhuravlev radar estimates were compromised by mistaken identification of internal reflectors as bottom reflectors at the higher frequencies used in the Svalbard surveys. In a later compilation, Zhuravlev (1985; HS0006) acknowledged these errors. He omitted 26 of the 57 glaciers, modified others and left the estimates for still others unchanged. The glaciers omitted by Zhuravlev are omitted here also. Those with modified estimates are referenced to Zhuravlev (1985) as source, and those that remained unchanged are referenced to Zhuravlev (1981). In three cases, Aldegondabreen, Fridtjovbreen and ??Austfonna, the Zhuravlev volumes have been replaced by more recent estimates.

Only the glacier name, area and mean thickness are from Zhuravlev's papers. Track density was taken from Figure 1 of Ekman (1971) for Austfonna, and for the 52 RES glaciers from the ratio of their total area to the total length of flightlines, about 2000 km, mentioned by Zhuravlev (1981); for the four glaciers studied in detail, track density was set arbitrarily to one tenth of this ratio. Other information comes from WGI-XF, guided in some cases by Hagen et al. (1993). The larger ice caps listed by Zhuravlev do not correspond to any one glacier in the inventory, and their physiography and codes were assigned by combining information on their components from Hagen et al.

HS0006 Zhuravlev 1985

This is a compilation of areas and volumes for 110 glaciers distributed around the world.

For Svalbard glaciers, see HS0005 Zhuravlev (1981).

HS0007 Björnsson 1981

Storglaciären   Track density from Figure 1.

Isfallsglaciären Track density from Figure 1.

Rabotsglaciär Track density is a rough estimate (1.5$Lmax$, given survey was along centreline and nine transverse lines).

HS0008 Nikitin et al. 2000a

S, H and V from Table 1; V is simply SH. $Zmin$, $Zmax$, $Lmax$, *PClass* and *Form* from WGI-XF. Several glaciers are presented as two branches, and in these cases $Lmax$ was assigned to the larger, and set to missing for the smaller, of the two. A number of misprints were corrected; for example H for SU5A15105242 is 50.3 m, not 5.5 m.

The fieldwork was done mainly in 1996 and 1997; the assigned date is 1996. It was not possible to distinguish the 34 glaciers with thicknesses based on maps derived from multiple transverse profiles from the 22 glaciers with thicknesses based on a single long profile. Therefore all the glaciers were assigned missing track densities, although $S/Lmax$ might be acceptable as a rough estimate.

HS0009 Su et al. 1984

S, $Hbar$ from Table 4; $V = S \times Hbar$. More glacier names may be recoverable from column 2 of Table 4. The first "5Y822C2" is actually 5Y822C0003. Track density is a rough estimate, $S/(Lmax + Wbar)$ from WGI-XF, based on Liu et al. 2003, who say that most of these glaciers were covered by a long profile and one or two transverse profiles.

HS0010 Navarro et al. 2005

Aldegondabreen All data from text except $Zmin$, $Zmax$ from Figure 1. Track density is $S/$ "about 40 km".

HS0011 Nikitin et al. 2000b

Relied on many of the glaciers reported by Nikitin et al. (2000a; HS0008), but added information on another 12 glaciers in basin 5A15105 and five in basin 5A15106. They also corrected apparently mistaken calculations for four glaciers in basin 5A15105, which were unreasonably thick for their areas. Similar mistakes, uncorrected, are suspected in the new measurements of glaciers 112, 115, 122 and 123 in 5A15106.

HS0012 Navarro et al. 2009

The Hurd Glacier of Navarro et al. (2009) corresponds roughly to glaciers 040, 041 and 042 of region AQ6C20107 of WGI-XF. S, H and V for both Hurd and Johnsons Glaciers were taken from Table 4, which also provides error estimates, and other information from WGI-XF. Field surveys were made between 1999 and 2004, but $Yend$ is entered as 2001 because later data were used only occasionally and were corrected for the evolution of mass balance. Track densities from Figure 2.

HS0013 Pattyn et al. 2009

S and H from the text. H was obtained by "simple arithmetic" on the ice-thickness map (Figure 3b); V is SH. $Zmin$, $Zmax$, $Lmax$, *PClass* and *Form* from WGI-XF. Track density from Figure 1.

HS0014 Binder et al. 2009

Kleinfleisskees includes a contiguous portion of Goldbergkees, detached from the main body of the latter. $Lmax$ measured on Figure 5, track density on Figure 3. Physiography from the text, except *PClass* and *Form* assigned by judgement.

HS0015 Ekman 1971

Ekman's seismic ground traverses were used by Zhuravlev 1985 (HS0006) to estimate, by methods that are not documented, the mean thickness of Austfonna and Vestfonna. The average of thicknesses at 39 seismic reflection stations on Austfonna is 428 m, so Zhuravlev's estimate of mean thickness, 312 m, must have involved mapping and extrapolation, and perhaps reliance on Soviet measurements although this is not stated.

HS0016 Glazovskij et al. 1991

Source for *S*, *Zmin*, *Zmax*, date, *Lmax* and track density (latter two from Figure 1) of Fridtjovbreen. *V* and *Hbar* from Macheret 2006.

HS0017 Dowdeswell et al. 1986

Data from the text, but volume and mean thickness calculated by measuring areas bounded by the 100m-interval isopachs of Figure 10 and assigning typical thicknesses (80 m for the region thinner than 100 m, 540 m for the region thicker than 500 m). Track density from Figure 4 (total track length of 3400 km less the 441 km on Vestfonna and smaller ice caps).

The track density is an order of magnitude less than that of the Ekman (HS0015) traverses, but the thickness obtained differs by only 2% from that of Zhuravlev (HS0006), suggesting that sampling at the Ekman density, with interpolation, may have been adequate. On the other hand, Ekman's 39 seismic stations yield an arithmetic average thickness 35%greater. Allowing each station to stand for 100 m of track, the implied track density of about 2×10^6 m^2 m^{-1} is evidently not adequate.

HS0018 Gergan et al. 1999

Most information from the paper itself. The glacier idcode and *Zmax* are from WGI-XF.

HS0019 Björnsson 1986

Most information from the paper itself; *Zmin*, *Zmax*, *Lmax* (summit to Mülajökull) from Figure 9. Track density is *S* divided by stated track length of 1350 km.

HS0020 Aric and Brückl 2001

S, *V* and *Lmax* from Table 1; $H = V/S$. Dates and other sources from the text of the paper. Track density from the text (three glaciers in the Dachstein massif) and Figure 9 (Gefrorenewandkees). *Zmin*, *Zmax*, *PClass* and *Form* from WGI-XF; Goldbergkees and Wurtenkees are subdivided by Aric and Brückl and so have incomplete (*Zmin*,*Zmax*) pairs.

Radar measurements by Fischer et al. 2007 (HS0041) make it clear that HS0020 underestimated the mean thickness of Vermuntgletscher and Brandnerferner, which were therefore relegated to HSV.GRAVEYARD.CSV.

HS0021 Thyssen and Kohnen 1968

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0022 Förtsch and Vidal 1958

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0023 Förtsch et al. 1955

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0024 Förtsch 1958

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0025 Förtsch and Vidal 1956

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0026 Förtsch and Vidal 1957

HS0027 Giese 1963

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0028 Brockamp 1958

Source cited by HS0020 Aric and Brückl 2001. Not yet seen [November 2010.]

HS0029 Cherkasov 1965

Source cited for two glaciers by HS0004 Macheret et al. 1988. Not yet seen [November 2010.]

HS0030 Brown et al. 2010

HS0031 Prinz et al. 2011

Information from text and figures. IdCode from WGI-XF. Method "RC" represents radar and cartography. Track density based on 26 GPR points and 100 m track per point.

HS0032 Fischer 2009

Information from text and Table 2. *Lmax* from Figure 2, IdCode from WGI-XF. Author's estimate accepted for estimating track density (100 m per GPR point).

HS0033 Brown et al. 1986

Quality very doubtful because Meier and Bahr's average thickness for the whole of Columbia Glacier appears to be based on soundings only of the lowest 7 km.

HS0034 Bælum and Benn 2010

Most information from the text and Table 1, but 1936-1938 *Lmax* and all *Zmin*, *Zmax* from WGI-XF. *TrackD* from paragraph 1 of section 3.1.

HS0035 Dowdeswell et al. 2002

Information from text, except *Lmax* from Figure 4a (stream A). *Hbar* is ratio of volume to area. Zhuravlev (1985, citing work of Bogorodskij from 1970 and 1978), gives only 1407 km^3 for volume, 67 pct of the Dowdeswell measurement.

Lmax for Otdel'nyj IC from Figure 5, *TrackD* from Figure 3; *Hbar* was obtained by digitizing the isopachs of Figure 6.

HS0036 Dowdeswell et al. 2004

Information from text, except *Lmax* from Figure 5 and *TrackD* estimated roughly for the western part from Figure 3.

HS0006 (Zhuravlev 1985, citing HS0039 Hyndman 1965 and Paterson and Koerner 1974) gives a much greater thickness of 526 m. The coverage in both of Zhuravlev's sources is very incomplete. Paterson and Koerner sounded over an area of about 80 km^2 near the highest point of the ice cap and offered no estimate of mean thickness. Hyndman's two north-south gravity traverses in the western part of the ice cap were the basis for his conjectural estimate of 3000–4500 km^3 for total ice-cap volume, but Zhuravlev gives a total of 6728 km^3.

HS0037 Rippin et al. 2003

Information from the text, especially p. 281, and from WGI-XF. The WGI-XF *Lmax* from 1977 is preferred to the 6000 m given in the text, but the text's 150 m of retreat is allowed for in the "1995" *Lmax*. *TrackD* obtained by estimating track length from numbers of 1990 and 1998 data points and their typical spacing.

HS0038 Span et al. 2005

See HS0042.

HS0039 Hyndman 1965

See HS0036.

HS0040 Paterson and Koerner 1974

HS0041 Macheret et al. 1999

Area and volume from Table 1; $Hbar = V/S$. Only those ice caps with measured volumes were taken. Following Sharov (1998), areas were reduced by 1.53% from the areas measured on 1:100 000-scale maps prepared from 1953 air photos. $Form$ set to 0 for ice caps of domal morphology and to 1 for those with outlet glaciers. Track lengths measured on Figure 1 and reduced to 80 percent to account for missing bed reflections. $Lmax$ also measured on Figure 1, but very crudely in the absence of contours. $Zmin$ assumed to be zero, $Zmax$ taken from a combination of WGI-XF and Wikipedia (need a decent regional map for this).

HS0042 Fischer et al. 2007

HS0038 reports thickness measurements on 21 glaciers, and HS0042 on 29. Figures showing the track coverage of the earlier seismic measurements in HS0020 are potentially valuable. For both sources, the most appropriate $Ybgn$ and $Yend$ are probably the date of the map of the surface topography. The radar measurements, at various later dates (1982 to 1997), were of thickness relative to this surface.

$IdCode$, $PClass$ and $Form$ taken from WGI-XF.

In HS0038, several of the glaciers appear to have sufficient density and coverage to make measurements of V possible, but only for Gepatschferner, Hintereisferner and Kesselwandferner is V estimated and stated explicitly. Information was taken from the text or from Table 1.1 of HS0038, with track lengths summed from the profile diagrams. It is not clear which of the two values of S given for Gepatschferner should be matched with the value of V, which comes from a Diplomarbeit at the University of Innsbruck. (Figure 2.33 is the ice thickness map, which could be digitized.) The volumes of Hintereisferner and Kesselwandferner are from Span and Kuhn (2003), where they are given without documentation of the method of calculation. The Hintereisferner data were merged with unpublished measurements of Wächter from 1982, and those for Kesselwandferner with unpublished measurements of Thyssen from 1985. For these three glaciers the HS0038 volumes appear more reliable than the earlier seismic measurements, which are relegated to HSV.DUPL.CSV.

HS0042 also gives no explicit mean thicknesses. For the glacieret Schwartzmilzferner, however, track density was sufficient to justify calculating an arithmetic average of the 22 radar measurements plotted in Figure 8.2. Four points of zero thickness were added to the 22 to represent peripheral thinning beyond the ends of the longitudinal and transverse profiles. A thickness map of Hochalmkees (Figure 7.15), with the 10-m isopach covering 2.49 km^2 of the stated total $S = 2.9$ km^2, was digitized and used to calculate the average thickness, 52 m. The uncovered 0.41 km^2 was assigned a thickness of 5 m; the mean thickness within the 10-m isopach was greater at 59 m.

Other glaciers for which track density might suffice for an estimate of mean thickness are Bachfallenferner, Jamtalferner, Langtalerferner, Nillkees, Untersulzbachkees, Obersulzbachkees and Schlatenkees.

It is clear from the measurements on Vermuntgletscher and Brandnerferner that the earlier seismic measurements of H in HS0020 are substantially underestimated. These two records were therefore relegated to HSV.GRAVEYARD.CSV.