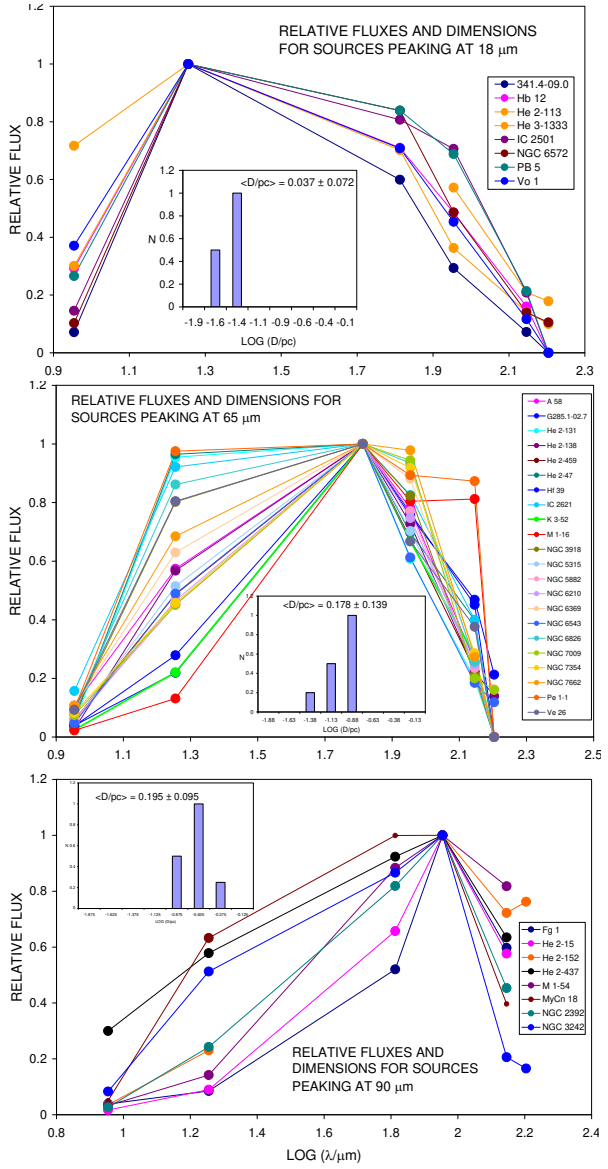

Fig. 4. An illustration of the variety of AKARI SEDs detected in the present analysis, where the sources are sorted with respect to the wavelength of peak emission. The sources in the top-most panel peak at 18 μm, whilst those in the middle and lower panels peak at 65 and 90 μm. There is therefore a cooling of the continua as one passes from the upper to the lower PNe. We have also included histograms and mean values of the nebular diameters D; where estimates for this parameter are taken from optical/radio observations. It is apparent that diameters are smaller for the upper SEDs, and shift to higher values for the lower SEDs. This trend is consistent with previous observations, and our later investigation of grain temperatures $T_{\rm GR}$. The color figure can be viewed online.

at 18 μm are shown in the upper panel, whilst those peaking at 65 and 90 μm are illustrated in the middle and lower graphs. We have also inserted histograms showing the distributions of sources with respect to intrinsic diameter, where the latter refers to the size of the ionized (radio/optical) emission envelope. It is clear that as the continua become cooler (i.e. the wavelength of peak FIR flux increases), so the sizes of the nebulae increase; precisely the trend which has been deduced from previous analyses of IRAS photometry. We shall consider this and further evolutionary trends in the following sections.

3.1. *Line and Band Contributions to the Nebular Fluxes*

FIR spectroscopy of PNe shows that most has continua dominated by emission from nebular grains, with temperatures $T_{\rm GR}$ of order ∼50–150 K. There is little doubt that these contribute the larger part of the emission in the present PNe, and we shall be assuming that this is the case for much of the analysis below. There are however several other bands and lines which are capable of affecting the results, and their contributions may be quite considerable. Thus for instance, the 9 μm IRC filter covers the regime of the PAH emission bands, and these are likely to contribute appreciable fluxes where C/O > 1. Evidence for these bands has been noted from ISO and Spitzer spectroscopy (e.g., Ramos-Larios, Phillips, & Cuesta 2011; Ramos-Larios et al. 2011, in preparation; Cohen & Barlow 2005), and there is evidence that much of the emission arises from PDRs.

The 18 μm filter, by contrast, includes [OIV] λ25.87 μm, [NeV] λ24.316 μm, and the $\lambda\lambda$18.713 and 33.482 μm transitions of [SIII]; the 21 and 30 μm emission features; and broad components associated with crystalline and amorphous silicates. The former (21 and 30 μm) features are found in PNe with C/O > 1, whilst silicates are formed in oxygen rich environments.

Perusal of *ISO*[1] pipeline spectra for 32 PNe reveals that a variety of other transitions affect the longer wave fluxes as well. These include [OIII] λ51.816 μm, [NII] λ57.317 μm, and [OI] λ63.184 μm (in the 65 and 90 μm channels); [OIII] λ88.355 μm (in the 90 μm channel); [NII] λ121.898 μm and [OI] λ145.526 μm (in the 140 μm and 160 μm channels); and [CII] λ157.741 μm (in the 160 μm passband).

Several of these transitions are strong, and may measurably affect the present results. Thus a de-

[1]Based on observations with ISO, an ESA project with instruments funded by ESA Member States (especially the PI countries: France, Germany, the Netherlands and the United Kingdom) and with the participation of ISAS and NASA.