



The Research and Impact of the Works by Don Nield

Sid Becker¹ · David Dempsey² · Dan Zhao

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Abstract

This is a commemoration of the work of Don Nield. His theoretical and applied mathematical models have had a tremendous impact in many fields including convection heat and mass transfer, stability analysis, nanofluid enhanced convection, and flows in porous media. Here the major contributions of Don Nield's Scopus-indexed outputs are reviewed. His research outputs and related impact are presented chronologically. The citation counts are presented with respect to each work published in that year. The work and impact of Don Nield as single author and in his collaborations are presented.

Keywords Don Nield · Commemorative · Porous media · Review

1 The Contributions of Don Nield

Don Nield was a prolific researcher and mathematician, and for more than 50 years, he made immense contributions to our understanding of convection, stability analysis, and transport processes in porous media (Nield 1964, 1966a, b, c, 1967, 1968a, b, 1974a, b, 1975, 1977, 1978, 1982, 1983a, b, 1987a, b, c, 1989, 1991a, b, c, 1993, 1994a, b, c, d, e, f, 1995a, b, 1994g, 1996, 1997, 1998a, b, c, d, 1999, 2000a, b, 2001a, b, c, d, 2002, 2003, 2004a, 2006a, b, 2007a, b, 2008a, b, c, 2004b, 2009a, b, c, d, 2011a, b, c, d, 2012, 2015, 2016; Joseph and Nield 1975; Joseph et al. 1982, 1983; Cohen and Nield 1985; Nield and Joseph 1985; Bejan and Nield 1991; Nield and Bejan 1992, 1999, 2006, 2013, 2017; Nield and Lage 1993, 1997, 1998; Manole et al. 1994; Nield et al. 1996, 1999, 2001, 2002, 2003a, b, 2004a, b, c, 2008, 2009, 2010, 2011, 2013, 2015, 2016; Lage et al. 1997a, b; Nield 1997; Lage and Nield 1998; Nield and Kuznetsov 1999, 2000, 2001a, b, 2003a, b, c, d, e, 2004a, b, c, 2005a, b, c, d, e, 2006a, b, c, d, 2007a, b, c, d, e, f, g, h, 2008a, b, c, d, 2009a, b, c, d, 2010a, b, c, d, e, f, 2011a, b, c, d, e, f, g, h, i, j, 2012a, b, 2013a, b, c, d, e, f, g, h, i, j, k, 2014a, b, c, d, e, f, 2015a, b, c, d, 2016a, b, c, d, 2019; Kuznetsov and Nield 2001, 2006a, b, 2008a, b, 2009a, b, c, 2010a, b, c, d, e, f, 2006c, 2011a, b, c, d, 2012a, b, 2013a,

✉ Sid Becker
sid.becker@canterbury.ac.nz

¹ Department of Mechanical Engineering, Faculty of Engineering, University of Canterbury, Christchurch, New Zealand

² Department of Civil and Natural Resources Engineering, Faculty of Engineering, University of Canterbury, Christchurch, New Zealand

b, c, 2014a, b, 2015, 2016; Narasimhan et al. 2001a, b; Kuznetsov et al. 2003, 2010, 2011, 2015; Haji-Sheikh et al. 2006; Nield and Hooman 2006; Avramenko et al. 2007; Hooman et al. 2007; Kelly et al. 2007; Love et al. 2007; Nield and Simmons 2007, 2019; Rees et al. 2008; Simmons et al. 2008, 2010; Vadasz and Nield 2008; Barletta and Nield 2009a, b, c, d, 2010a, b, 2011a, b, a, b, c, d, 2009, 2010a, b, 2012; Barletta et al. 2010, 2011, 2014, 2016; Rees and Nield 2016). Don was a mathematician based in the University of Auckland's Department of Engineering Science and the breadth and impact of his research is an inspiration. Some of his earliest papers, which have been cited more than 500 times, concern buoyancy in convection, and these would eventually lead him to his major body of work on stability analysis and the onset of convection (often in porous media). Don's work related to convection in nanofluid-saturated porous media has been transformative in advancing the field's knowledge of both theoretical and applied heat transfer, and in this, he effectively started an entire field. Don published over 190 works related to flow in porous media, over 160 of which concerned convection heat transfer. About one-third of Don's publications were related to stability analysis and the onset of convection—and much of this helped to develop the field of nanofluids in porous media. His research on double-diffusive convection reshaped conventional theories of multi-phase flow and convective heat transfer. He integrated solute concentration and temperature gradients into porous media transport models, providing an explicit view of how these factors interact to influence stability and flow behaviour in complex systems.

Don developed analytical models that investigated the influence of Brownian motion and thermophoresis in boundary layer flow (Nield and Kuznetsov 2009b, 2011i; Kuznetsov and Nield 2010c, 2013c, 2014a). He presented critical analyses of commonly held modelling approaches such as the applicability of the Brinkman–Forchheimer equation (Nield 1991c). Don's work contributed to our understanding of stability analysis (Manole et al. 1994; Nield 2003, 2011b; Nield and Kuznetsov 2006a, 2007c, e, 2009a, 2010c, d, 2011c, e, f, g, h, 2012a, b, c, e, f, g, i, 2014b, f, 2015a, b, 2016a, b, c; Barletta and Nield 2009b, 2010a, b, 2011a, b, 2012a, b, d; Nield and Barletta 2009, 2012; Barletta et al. 2010, 2011, 2016; Kuznetsov and Nield 2010b, d, f, 2011a, b, 2012a, b, 2013a, b, 2014b, 2015, 2016; Simmons et al. 2010; Kuznetsov et al. 2011, 2015; Nield et al. 2011, 2015, 2016) both in non-porous (Barletta and Nield 2009b, 2010b, 2012d; Nield and Kuznetsov 2010c, 2011e, 2013c; Barletta et al. 2011; Nield and Barletta 2012; Kuznetsov and Nield 2016) and porous media (Manole et al. 1994; Nield 2003, 2011b; Nield and Kuznetsov 2006a, 2007c, e, 2009a, 2010d, 2011c, f, g, h, 2012a, b, 2013e, f, g, i, 2014b, f, 2015a, b, 2016a, b, c; Nield and Barletta 2009; Barletta et al. 2010, 2016; Barletta and Nield 2010a, 2011a, b, 2012a, b; Kuznetsov and Nield 2010b, d, f, 2011a, b, 2012a, b, 2013a, b, 2014b, 2015; Simmons et al. 2010; Kuznetsov et al. 2011, 2015; Nield et al. 2011, 2015, 2016). He developed models of thermal instability of nanofluid flows in porous media (Nield and Kuznetsov 2009a, 2011c, 2014b, 2015b; Kuznetsov and Nield 2010f) and in the fundamental plane channel Poiseuille flow (Barletta et al. 2011; Nield and Barletta 2012). Many of his contributions focused on determining the conditions required for the onset of convection in porous media (Nield 1968b, 1977, 1982, 1995b, 1996, 1998c, 2007a, 2011a, d; Nield et al. 2004a, 2009, 2010, 2011, 2015, 2016; Nield and Kuznetsov 2006a, 2007b, c, d, e, f, h, 2008c, d, 2010b, d, 2011a, f, g, h, 2012a, b, 2013b, e, f, g, i, 2014f, 2015a, 2016a, c, 2019; Nield and Simmons 2007; Kuznetsov and Nield 2008a, 2010b, d, 2011a, b, d, 2012a, b, 2013a, b, 2014b, 2015; Kuznetsov et al. 2010, 2011, 2015; Simmons et al. 2010; Rees and Nield 2016) and in the non-porous domain (Nield 1975; Nield and Kuznetsov 2006c, 2010a, c, 2011e, 2013c, 2014d, e; Barletta et al. 2011; Kuznetsov and Nield 2016). Don also produced many works on nanofluid flow (Nield and Kuznetsov 2009a, b, 2010a, c,

2011c, e, i, 2012a, 2013a, g, k, 2014b, c, d, e, 2015b, c, d; Kuznetsov and Nield 2010b, c, d, f, 2011a, c, 2013c, 2014a; Nield 2011a).

His rigorous approach to investigating complex, multi-dimensional phenomena in porous media and nanofluids has left an enduring influence on our understanding of convection in porous media and complex flow. By examining the influence of Brownian motion and thermophoresis on the onset of convection, Nield's work developed what would become the current understanding of convective heat transfer, especially in nanofluid systems (Nield and Kuznetsov 2009a, b, 2010a, c, 2011c, e, i, 2012a, 2013g, 2014d, e; Kuznetsov and Nield 2010b, c, d, f, 2011a, c, 2013c, 2014a; Nield 2011a). His work provided significant insights into the complex dynamics of natural and double-diffusive convection (Kuznetsov and Nield 2011c, 2012a; Nield and Kuznetsov 2011e, 2013c, 2013i, 2016b; Kuznetsov et al. 2015; Nield et al. 2015). He showed that oscillatory instability in nanofluid systems can occur when the nanoparticle distribution is bottom-heavy, with the effect of nanoparticles primarily influencing buoyancy rather than the thermal energy equation and that oscillatory convection can be suppressed by modifying the boundary conditions for nanoparticle flux and that non-oscillatory convection is destabilized by the presence of nanoparticles (Nield and Kuznetsov 2006c, 2009a, 2010c, f, 2011c, 2013c, 2014b, d, 2015b, 2016b; Kuznetsov and Nield 2010f; Nield et al. 2015). Don addressed the onset of convection in nanofluid-saturated porous media, incorporating the effects of Brownian motion, thermophoresis, and local thermal non-equilibrium (LTNE) and showed that while LTNE effects are significant, in some cases, they are generally minimal for typical dilute nanofluids (Nield 1998d; Kuznetsov and Nield 2011a). Additionally, Don extended the Rayleigh–Bénard theory to new convection models, providing new analytical expressions for stability boundaries (Nield 1966a, b, 1987a, 1994b, 1997; Barletta and Nield 2009b).

It is impossible to fully quantify the impact that Don's work has had on the field of thermal fluid sciences and porous media. However, in the sections that follow, we consider some metrics—such as citation counts, publication numbers, and collaborations—that help place his influence in context.

Don was a prolific author. His total number of works exceeds 270, nearly all of which are Scopus-indexed (Nield 1964, 1966a, b, c, 1967, 1968a, b, 1974a, b, 1975, 1977, 1978, 1982, 1983a, b, 1987a, b, c, 1989, 1991a, b, c, 1993, 1994a, b, c, d, e, f, 1995a, b, 1994g, 1996, 1997, 1998a, b, c, d, 1999, 2000a, b, 2001a, b, c, d, 2002, 2003, 2004a, 2006a, b, 2007a, b, 2008a, b, c, 2004b, 2009a, b, c, d, 2011a, b, c, d, 2012, 2015, 2016; Joseph and Nield 1975; Joseph et al. 1982, 1983; Cohen and Nield 1985; Nield and Joseph 1985; Bejan and Nield 1991; Nield and Bejan 1992, 1999, 2006, 2013, 2017; Nield and Lage 1993, 1997, 1998; Manole et al. 1994; Nield et al. 1996, 1999, 2001, 2002, 2003a, b, a, b, 2004c, 2008, 2009, 2010, 2011, 2013, 2015, 2016; Lage et al. 1997a, b; Nield 1997; Lage and Nield 1998; Nield and Kuznetsov 1999, 2000, 2001a, b, 2003a, b, c, d, e, 2004a, b, c, a, b, c, d, e, 2006a, b, c, d, 2007a, b, c, d, e, f, g, h, 2008a, b, c, d, 2009a, b, c, d, 2010a, b, c, d, e, f, 2011a, b, c, d, e, f, g, h, i, j, 2012a, b, 2013a, b, c, d, e, f, g, h, i, j, k, 2014a, b, c, d, e, f, 2015a, b, c, d, 2016a, b, c, 2019; Kuznetsov and Nield 2001, 2006a, b, 2008a, b, 2009a, b, c, 2010a, b, c, d, e, f, 2006c, 2011a, b, c, d, 2012a, b, 2013a, b, c, 2014a, b, 2015, 2016; Narasimhan et al. 2001a, b; Kuznetsov et al. 2003, 2010, 2011, 2015; Haji-Sheikh et al. 2006; Nield and Hooman 2006; Avramenko et al. 2007; Hooman et al. 2007; Kelly et al. 2007; Love et al. 2007; Nield and Simmons 2007, 2019; Rees et al. 2008; Simmons et al. 2008, 2010; Vadasz and Nield 2008; Barletta and Nield 2009a, b, c, d, 2010a, b, 2011a, b, 2012a, b, c, d; Nield and Barletta 2009, 2010a, b, 2012; Barletta et al. 2010, 2011, 2014, 2016; Rees and Nield 2016). His contributions have had enormous impact on the field. To date, his total

citation count exceeds 22,000, and his top citation is nearly 7000. Twenty of his works have been cited more than 200 times, and thirty-five of his works have been cited more than 100 times. To provide a timeline context, Fig. 1 presents the annual number works Don produced along with the total (to date) citations of works published that year.

1.1 As Single Author

As single author Don published a total of 70 Scopus-indexed works, which have accumulated nearly 4000 citations (Nield 1964, 1966a, b, c, 1967, 1968a, b, 1974a, b, 1975, 1977, 1978, 1982, 1983a, b, 1987a, b, c, 1989, 1991a, b, c, 1993, 1994a, b, c, d, e, f, 1995a, b, 1994g, 1996, 1997, 1998a, b, c, d, 1999, 2000a, b, 2001a, b, c, d, 2002, 2003, 2004a, 2006a, b, 2007a, b, 2008a, b, c, 2004b, 2009a, b, c, d, 2011a, b, c, d, 2012, 2015, 2016; Nield 1997). Of these, 22 have been cited 50 or more times, and 9 have been cited more than 100 times. A depiction of his Scopus-indexed works and their associated citations is presented in Fig. 2. Here, the number of Don's works per year is presented, along with the total (to date) citations of works published that year. Even his very early works had high impact; his 1964 publication "*Surface Tension and Buoyancy Effects in Cellular Convection*" (Nield 1964) has been cited more than 500 times, and his 1968 "*Onset of Thermohaline Convection in a Porous Medium*" (Nield 1968b) has been cited more than 550 times. These clearly indicate the research themes of porous media, and convection heat transfer that would be seen in his many later contributions. His most influential works as an independent author focused primarily on forced convection, thermal non-equilibrium, and double-diffusive convection, with applications in porous media and nanofluids. His work has provided important insights into boundary conditions, stability analysis, and viscous dissipation in fluid flow.

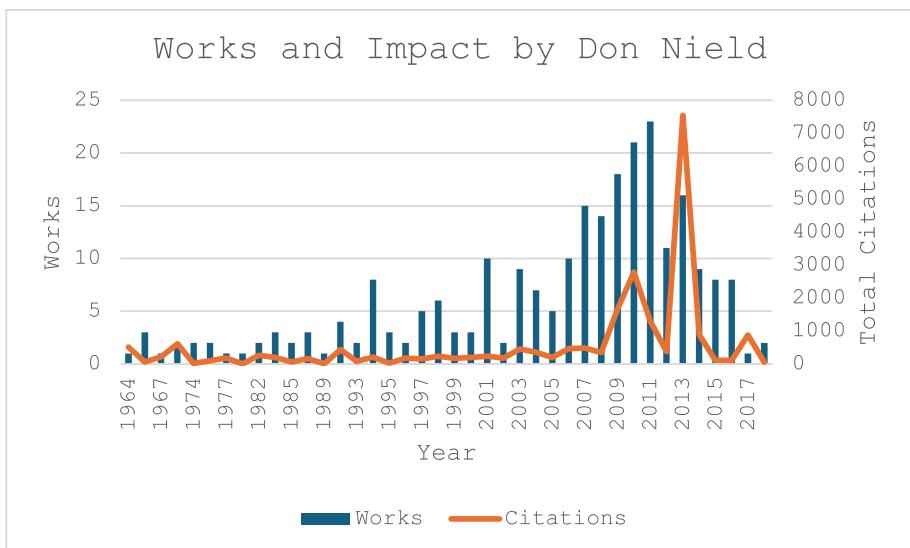


Fig. 1 SCOPUS-indexed works per year and the number of citations (to date) of each work published that year

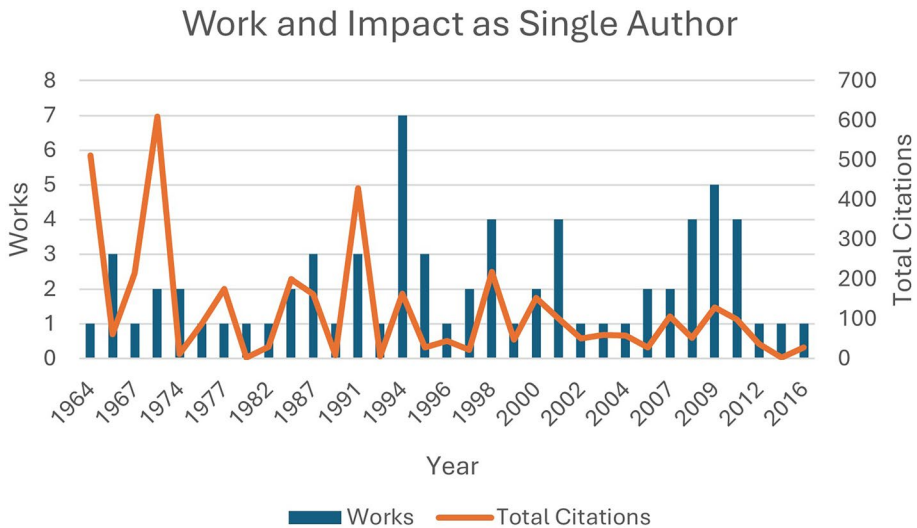


Fig. 2 Scopus-indexed works and impact of Don Nield as single author. Impact is presented as the number of times works published that year have been cited to date

1.2 Collaborations

While Don was prolific as an independent researcher, he also collaborated frequently with select world-renowned researchers. Because Don was fundamentally a mathematician, it was in his collaborations that he published results from computational heat and mass transfer models. A summary of Don's Scopus-indexed works with a focus on his notable collaborations is displayed in Table 1. The table first lists Don's total works and impact, and then those as single author. These are followed by works produced with his 26 collaborators. The table lists the number of works of these collaborations and the total (to date) citation number of those collaborations. His collaborators' names are easily recognized as renowned researchers in the fields of analytical and applied mathematics, fluid dynamics, heat and mass transfer, and, of course, the fundamentals and modelling of flow in porous media.

1.3 Nield and Bejan (1991–2017)

The collaboration between Donald A. Nield and Adrian Bejan on the book, *Convection in Porous Media*, has resulted a cornerstone in the field of fluid mechanics and heat transfer. Their work has made a lasting impact, providing a comprehensive overview of the current understanding of flows in porous media and descriptions of recent advances in both theory and application. Over the course of five editions, the 1st published in 1992 (Nield and Bejan 1992), the 2nd in 1999 (Nield and Bejan 1999), the 3rd in 2006 (Nield and Bejan 2006), the 4th in 2012 (Nield and Bejan 2013), and the 5th in 2017 (Nield and Bejan 2017), Don and Adrian developed what has become a primary text to introduce many researchers to the fundamentals underlying heat and mass transfer in porous media. The

Table 1 SCOPUS-indexed works by Don Nield and his collaborations

Surname	Total works	Total citations
Nield, D.A	249	22,480
Nield, D.A. (As Single Author)	70	3921
Kuznetsov, A.V	128	8979
Bejan, A	4	8056
Xiong, M	5	537
Lage, J.L	12	497
Barletta, A	24	473
Simmons, C.T	11	326
Joseph, D.D	4	302
Papanicolaou, G	2	238
Celli, M	8	154
Junqueira, S.L.M	1	134
Hooman, K	3	133
Antohe, B.V	2	125
Haji-Sheikh, A	2	122
Ming, X	1	85
Narasimhan, A	3	60
Porneala, D.C	3	53
Rees, D.A.S	2	52
Manole, D.M	1	41
Avramenko, A.A	2	38
Ward, J.D	1	38
Sharp Jr., J.M	1	33
Love, A.J	1	26
Vadasz, P	1	4
Cohen, Y	1	2
Johnson, C.J	1	1
Kelly, P.A	1	1

books have had a tremendous impact. To date, the editions have been cited over 10,000 times with the 2012 edition cited over 6,900 times. With each update, they expanded the scope of the book to include topics such as the heat transfer properties of nanofluids and applications involving local thermal non-equilibrium and microfluidic effects. Nield and Bejan's legacies through their contributions have made a profound impact, not only in academic circles but also in practical engineering applications, where their work is frequently referenced in the design and analysis of systems involving porous media.

1.3.1 Nield and Kuznetsov (1999–2017)

The remarkable collaboration between Don Nield and Andrey Kuznetsov lasted more than 20 years. Their collaborative works have greatly advanced the field's understanding of convection in porous media, with key contributions in nanofluids, double-diffusive convection, and forced convection. The integration of nanofluids into convection analysis extended classical theories by including the effects of Brownian motion and

thermophoresis. The collaborative team is also credited with the advancement of the concept of double-diffusive convection in porous media, often in applications of natural convection and Brownian motion where both temperature and solute concentration gradients influence fluid movement. Their work on forced convection in porous media, particularly through the application of the Graetz methodology to parallel-plate channels, has improved heat transfer efficiency in industrial heat exchangers and filtration systems. These contributions have had a lasting impact on the field of convection in porous media, with their research continuing to shape both academic studies and practical applications in engineering.

The body of work produced by Nield and Kuznetsov is impressive, spanning over two decades and including four book chapters (Nield and Kuznetsov 2005b, e, c, d) and over 120 Scopus-indexed papers (Nield and Kuznetsov 1999, 2000, 2001a, b, 2003a, b, c, d, e, 2004a, b, c, 2005a, c, d, 2006a, b, c, d, 2007a, b, c, d, e, f, g, h, 2008a, b, c, d, 2009a, b, c, d, 2010a, b, c, d, e, f, 2011a, b, c, d, e, 2011f, g, h, i, j, 2012a, b, a, b, c, d, e, f, g, h, i, j, k, 2014a, b, c, d, e, f, 2015a, b, 2016a, b, c, 2019; Kuznetsov and Nield 2001, 2006a, b, 2008a, b, 2009a, b, c, 2010a, b, c, d, e, f, 2006c, 2011a, b, c, d, 2012a, b, 2013a, b, c, 2014a, b, 2015, 2016; Nield et al. 2002, a, b, 2004a, b, c, 2008, 2009, 2010, 2013, 2015, 2016; Kuznetsov et al. 2003, 2010, 2011, 2015; Avramenko et al. 2007; Rees et al. 2008; Simmons et al. 2010; Barletta et al. 2016). A chronological depiction of works and impact is presented in Fig. 3. Here, the number of their works per year is presented along with the total (to date) citations of works published that year. Their earliest work was published in 1999 and their annual productivity steadily rose peaking with 16 publications in 2010 alone (Kuznetsov and Nield 2010a, b, c, d, e, f, 2006c; Kuznetsov et al. 2010; Nield and Kuznetsov 2010a, b, c, d, e, f; Nield et al. 2010; Simmons et al. 2010). With a total of more than 9000 citations, their works are highly influential. They wrote seventeen papers that have each been cited over 100 times. Their 2010 paper “Natural convective boundary-layer flow of a nanofluid past a vertical plate” (Kuznetsov and Nield 2010c) published in the *International Journal of Thermal Sciences* has been cited 1,387 times to date.

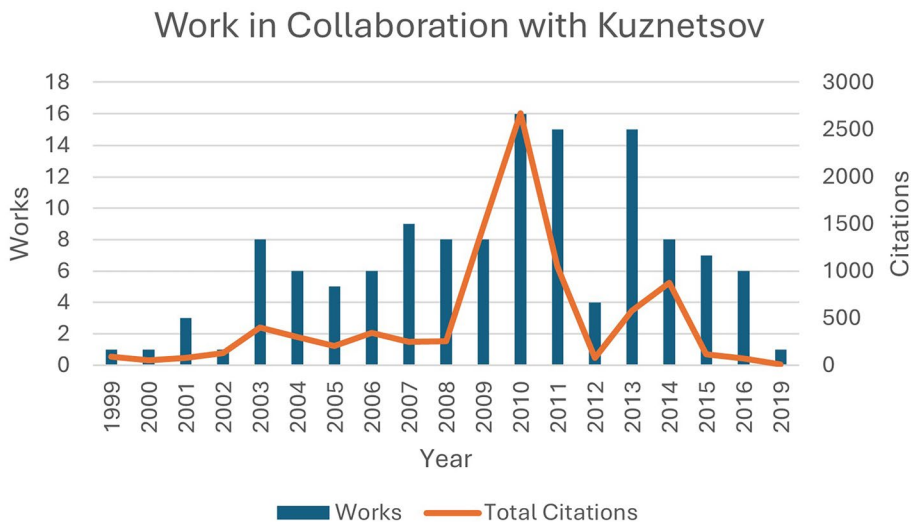


Fig. 3 SCOPUS-indexed works and impact of Don Nield with Andrey Kuznetsov. Impact is presented as the number of times works published that year have been cited to date

As Andrey's research student (2002–2007), Sid Becker, recalls an inside glimpse of the operation behind this prolific collaboration. Don worked from Auckland, New Zealand—and Andrey from Raleigh, North Carolina—a time difference between them of more than 12 h. As both were incredibly dedicated researchers working long hours, their collaboration continued without interruption: when Don stopped work, he would send his updates to Andrey, who would be beginning his day. For years, their work literally went on around the clock!

1.4 Memorandum

Don Nield's lifelong dedication to the study of convection and porous media has left an indelible mark on the thermal sciences. His prolific output, deep theoretical insights, and collaborative spirit shaped an entire field and inspired generations of researchers. As this commemoration reflects, his legacy lives on through the enduring relevance of his work and the many scholars who continue to build upon it.

Don is deeply missed by the scientific community, his collaborators, and the many students and colleagues who were privileged to work with him.

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Declarations

Conflict of interest The authors have not disclosed any competing interests.

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