

## List of Publications

1. \* **Pawan Kumar**, Melinda Nagy, Alexandre Lemerle, Bidya Binay Karak, & Kristof Petrovay “The Polar Precursor Method for Solar Cycle Prediction: Comparison of Predictors and Their Temporal Range” *ApJ* (2021) 909:87
2. † **Pawan Kumar**, Bidya Binay Karak, & Vindya Vashishth “Supercriticality of the Dynamo Limits the Memory of the Polar Field to One Cycle” *ApJ* (2021) 913:65
3. Alexander V Mordvinov, Bidya Binay Karak, Dipankar Banerjee, Elena M Golubeva, Anna Khlystova, Anastasiya V Zhukova, & **Pawan Kumar** “Evolution of the Sun’s activity and the poleward transport of remnant magnetic flux in Cycles 21-24” *MNRAS* (2022) 510:1
4. ‡ **Pawan Kumar**, Akash Biswas, & Bidya Binay Karak, “Physical link of the polar field buildup with the Waldmeier effect broadens the scope of early solar cycle prediction: Cycle 25 is likely to be slightly stronger than Cycle 24” *MNRAS* (2022) 513:1
5. Elena M Golubeva, Akash Biswas, Anna I Khlystova, **Pawan Kumar**, & Bidya Binay Karak, “Probing the variations in the timing of the Sun’s polar magnetic field reversals through observations and surface flux transport simulations” *MNRAS* (2023) 525:2

---

\*Presented in Chapter 3

†Presented in Chapter 5

‡Presented in Chapter 4

6. Akash Biswas, Bidya Binay Karak, & **Pawan Kumar**, “Exploring the reliability of polar field rise rate as a precursor for an early prediction of solar cycle”; [Accepted; MNRAS \(2023\)](#)
7. § **Pawan Kumar**, Bidya Binay Karak, & Anu Sreedevi, “Variabilities in the polar field and solar cycle due to irregular properties of Bipolar Magnetic Regions”, [Submitted; MNRAS \(2023\)](#)

---

§Presented in Chapter 2

## Conferences / Presentations

1. Presented an oral talk titled "**Solar cycle variability induced by stochastic fluctuations of BMR properties and at different amounts of dynamo supercriticality**", IAU Symposium 365, 21–25 August 2023, Yerevan, Armenia
2. Presented a poster titled "**How supercritical is the solar dynamo?**", IAU Symposium 365, 21–25 August 2023, Yerevan, Armenia
3. Presented an oral talk titled "**Effect of irregular properties of BMR on the polar field and solar cycle variability**", ISSI Team meeting, 10–14 July 2023, Bern, Switzerland (Online)
4. Presented a poster titled "**Effect of irregular bipolar magnetic region emergence and tilt scatter on the polar magnetic field and the solar cycle**", 41<sup>th</sup> Annual Meeting of the Astronomical Society of India (ASI), 1–5 March 2023, IIT Indore, Indore, India
5. Presented an oral talk titled "**Supercriticality of the dynamo limits the memory of the polar field to one cycle**", Young Astronomers Meet, 9–13 November 2022, Aries, Nainital, India
6. Presented an oral talk titled "**Solar cycle prediction using different predictors**", Aditya-L1 Science Support Cell Workshop, 27 June–6 July 2022, Aries, Nainital, India
7. Presented an oral talk titled "**Physical link of the polar field rise rate with the Waldmeier effect broadens the scope of early solar cycle prediction: Cycle**

- 
- 25 is likely to be slightly stronger than Cycle 24"**, 40<sup>th</sup> Annual Meeting of the Astronomical Society of India (ASI), 25–29 March 2022, IIT Roorkee, Roorkee, India
8. Presented an oral talk titled "**Polar precursor method for solar cycle prediction: comparison of predictors and their temporal range**", 15<sup>th</sup> Quadrennial Solar-Terrestrial Physics Symposium (STP-15), 21–25 February 2022 (Online)
  9. Presented an oral talk titled "**How early can we predict the solar cycle strength reliably using the polar precursor method?**", 2<sup>nd</sup> International Symposium on Space Science (ISSS - 21), 15 November 2021 (Online)
  10. Presented a poster titled "**The polar precursor method for solar cycle prediction: comparison of predictors and their temporal range**", 16<sup>th</sup> European Solar Physics Meeting (ESPM–16), 6–10 September 2021 (Online)
  11. Participated in the High-End Workshop titled "**Solar Activities And Their Influences in the Heliosphere And Planetary Atmospheres**", 8–14 March 2021 (Online)
  12. Presented a poster titled "**The polar precursor method for solar cycle prediction: comparison of predictors and their temporal range**", in the conference titled *Advances in Observations And Modelling of Solar Magnetism and Variability*, 1–4 March 2021 (Online)
  13. Presented a poster titled "**Precursor method for solar cycle prediction: comparison of predictors and their temporal range**", in 39<sup>th</sup> Annual Meeting of the Astronomical Society of India (ASI), 18–23 February 2021 (Online)

# References

- Alfvén H., 1943, Arkiv for Matematik, Astronomi och Fysik, 29B, 1
- Babcock H. D., 1959, Astrophysical Journal, 130, 364
- Babcock H. W., 1961, Astrophysical Journal, 133, 572
- Babcock H. D., Livingston W. C., 1958, Science, 127, 1058
- Bertello L., Pevtsov A. A., Petrie G. J. D., Keys D., 2014, Solar Physics, 289, 2419
- Bhowmik P., Nandy D., 2018, Nature Communications, 9, 5209
- Biswas A., Karak B. B., Kumar P., 2023a, arXiv e-prints, p. arXiv:2308.01155
- Biswas A., Karak B. B., Usoskin I., Weisshaar E., 2023b, Space Science Reviews, 219, 19
- Bradshaw S. J., Hartigan P., 2014, Astrophysical Journal, 795, 79
- Cameron R., Schüssler M., 2007, Astrophysical Journal, 659, 801
- Cameron R., Schüssler M., 2008, Astrophysical Journal, 685, 1291
- Cameron R., Schüssler M., 2015, Science, 347, 1333
- Cameron R. H., Schüssler M., 2016, Astronomy and Astrophysics, 591, A46
- Cameron R. H., Schüssler M., 2017a, Astrophysical Journal, 843, 111
- Cameron R. H., Schüssler M., 2017b, Astrophysical Journal, 843, 111
- Cameron R., Schüssler M., 2023, arXiv e-prints, p. arXiv:2305.02253
- Cameron R. H., Schmitt D., Jiang J., Işık E., 2012, Astronomy and Astrophysics, 542, A127
- Cameron R. H., Dasi-Espuig M., Jiang J., Işık E., Schmitt D., Schüssler M., 2013, Astronomy and Astrophysics, 557, A141
- Cameron R. H., Duvall T. L., Schüssler M., Schunker H., 2018, Astronomy and Astrophysics, 609, A56
- Chae J., Litvinenko Y. E., Sakurai T., 2008, Astrophysical Journal, 683, 1153

- Chandrasekhar S., 1952, *Publications of the ASP*, 67, 98
- Chandrasekhar S., 1961, *Hydrodynamic and hydromagnetic stability*
- Charbonneau P., 2014, *Ann. Rev. Astron. Astrophys.*, 52, 251
- Charbonneau P., 2020, *Living Reviews in Solar Physics*, 17, 4
- Charbonneau P., Barlet G., 2011, *Journal of Atmospheric and Solar-Terrestrial Physics*, 73, 198
- Charbonneau P., Dikpati M., 2000, *Astrophysical Journal*, 543, 1027
- Chatterjee P., Nandy D., Choudhuri A. R., 2004, *Astronomy and Astrophysics*, 427, 1019
- Chatzistergos T., Krivova N. A., Ermolli I., 2022, *Frontiers in Astronomy and Space Sciences*, 9
- Choudhuri A. R., 1998, *The physics of fluids and plasmas : an introduction for astrophysicists /*
- Choudhuri A. R., 2003, *Solar Physics*, 215, 31
- Choudhuri A. R., 2018, *Journal of Atmospheric and Solar-Terrestrial Physics*, 176, 5
- Choudhuri A. R., 2021, *Science China Physics, Mechanics, and Astronomy*, 64, 239601
- Choudhuri A. R., Gilman P. A., 1987, *Astrophysical Journal*, 316, 788
- Choudhuri A. R., Hazra G., 2016, *Advances in Space Research*, 58, 1560
- Choudhuri A. R., Nandy D., Chatterjee P., 2005, *Astronomy and Astrophysics*, 437, 703
- Choudhuri A. R., Chatterjee P., Jiang J., 2007, *Physical Review Letters*, 98, 131103
- D'Silva S., Choudhuri A. R., 1993, *Astronomy and Astrophysics*, 272, 621
- Dasi-Espuig M., Solanki S. K., Krivova N. A., Cameron R., Peñuela T., 2010, *Astronomy and Astrophysics*, 518, A7
- Dikpati M., Charbonneau P., 1999, *Astrophysical Journal*, 518, 508
- Dikpati M., Corbard T., Thompson M. J., Gilman P. A., 2002, *Astrophysical Journal, Letters*, 575, L41
- Dikpati M., Gilman P. A., de Toma G., 2008, *Astrophysical Journal, Letters*, 673, L99
- Eddy J. A., 1976, *Science*, 192, 1189
- Fang T.-W., et al., 2022, *Space Weather*, 20, e2022SW003193
- Featherstone N. A., Miesch M. S., 2015, *Astrophysical Journal*, 804, 67
- Garg S., Karak B. B., Egeland R., Soon W., Baliunas S., 2019, *Astrophysical Journal*, 886, 132

- Gizon L., Cameron R. H., Pourabdian M., Liang Z.-C., Fournier D., Birch A. C., Hanson C. S., 2020, *Science*, 368, 1469
- Golubeva E. M., Biswas A., Khlystova A. I., Kumar P., Karak B. B., 2023, arXiv e-prints, p. arXiv:2307.13452
- Gopalswamy N., Mäkelä P., Yashiro S., Akiyama S., 2018, *Journal of Atmospheric and Solar-Terrestrial Physics*, 176, 26
- Guerrero G., Dikpati M., de Gouveia Dal Pino E. M., 2009, *Astrophysical Journal*, 701, 725
- Guo W., Jiang J., Wang J.-X., 2021, *Solar Physics*, 296, 136
- Gurgenashvili E., et al., 2016, *The Astrophysical Journal*, 826, 55
- Hale G. E., 1908, *Astrophysical Journal*, 28, 315
- Hale G. E., Ellerman F., Nicholson S. B., Joy A. H., 1919, *Astrophysical Journal*, 49, 153
- Hathaway D. H., 2015, *Living Reviews in Solar Physics*, 12, 4
- Hathaway D. H., Upton L., 2014, *Journal of Geophysical Research (Space Physics)*, 119, 3316
- Hathaway D. H., Wilson R. M., Reichmann E. J., 2002a, *Solar Physics*, 211, 357
- Hathaway D. H., Wilson R. M., Reichmann E. J., 2002b, *Solar Physics*, 211, 357
- Hazra G., Choudhuri A. R., 2019, *Astrophysical Journal*, 880, 113
- Hazra S., Passos D., Nandy D., 2014, *Astrophysical Journal*, 789, 5
- Hazra G., Karak B. B., Banerjee D., Choudhuri A. R., 2015, *Solar Physics*, 290, 1851
- Hazra G., Choudhuri A. R., Miesch M. S., 2017, *Astrophysical Journal*, 835, 39
- Hazra S., Brun A. S., Nandy D., 2020, *Astronomy and Astrophysics*, 642, A51
- Hazra G., Nandy D., Kitchatinov L., Choudhuri A. R., 2023, *Space Science Reviews*, 219, 39
- Hotta H., Yokoyama T., 2010, *Astrophysical Journal*, 709, 1009
- Howard R. F., 1991, *Solar Physics*, 136, 251
- Howe R., 2009, *Living Reviews in Solar Physics*, 6, 1
- Howe R., 2020, in Monteiro M. J. P. F. G., García R. A., Christensen-Dalsgaard J., McIntosh S. W., eds, *Astrophysics and Space Science Proceedings Vol. 57, Dynamics of the Sun and Stars; Honoring the Life and Work of Michael J. Thompson*. pp 63–74, doi:10.1007/978-3-030-55336-4\_8

- Iijima H., Hotta H., Imada S., Kusano K., Shiota D., 2017, *Astronomy and Astrophysics*, 607, L2
- Jha B. K., Karak B. B., Mandal S., Banerjee D., 2020, *Astrophysical Journal, Letters*, 889, L19
- Jiang J., 2020, *Astrophysical Journal*, 900, 19
- Jiang J., Chatterjee P., Choudhuri A. R., 2007, *Monthly Notices of the RAS*, 381, 1527
- Jiang J., Cameron R. H., Schüssler M., 2014, *Astrophysical Journal*, 791, 5
- Jiang J., Wang J.-X., Jiao Q.-R., Cao J.-B., 2018, *The Astrophysical Journal*, 863, 159
- Jouve L., Brown B. P., Brun A. S., 2010a, *Astronomy and Astrophysics*, 509, A32
- Jouve L., Proctor M. R. E., Lesur G., 2010b, *Astronomy and Astrophysics*, 519, A68
- Kane R. P., 2010, *Solar Physics*, 261, 209
- Käpylä M. J., Käpylä P. J., Olsper N., Brandenburg A., Warnecke J., Karak B. B., Pelt J., 2016, *Astronomy and Astrophysics*, 589, A56
- Karak B. B., 2010, *Astrophysical Journal*, 724, 1021
- Karak B. B., 2020, *The Astrophysical Journal Letters*, 901, L35
- Karak B. B., 2023, *Living Reviews in Solar Physics*
- Karak B. B., Cameron R., 2016, *Astrophysical Journal*, 832, 94
- Karak B. B., Choudhuri A. R., 2011, *Monthly Notices of the RAS*, 410, 1503
- Karak B. B., Miesch M., 2017, *Astrophysical Journal*, 847, 69
- Karak B. B., Miesch M., 2018, *Astrophysical Journal, Letters*, 860, L26
- Karak B. B., Nandy D., 2012, *Astrophysical Journal, Letters*, 761, L13
- Karak B. B., Jiang J., Miesch M. S., Charbonneau P., Choudhuri A. R., 2014, *Space Science Reviews*, 186, 561
- Karak B. B., Käpylä P. J., Käpylä M. J., Brandenburg A., Olsper N., Pelt J., 2015a, *Astronomy and Astrophysics*, 576, A26
- Karak B. B., Kitchatinov L. L., Brandenburg A., 2015b, *Astrophysical Journal*, 803, 95
- Karak B. B., Mandal S., Banerjee D., 2018, *Astrophysical Journal*, 866, 17
- Khodairy S., Sharaf M., Awad M., Abdel Hamed R., Hussein M., 2020, in *Journal of Physics Conference Series*. p. 012010, doi:10.1088/1742-6596/1523/1/012010
- Kitchatinov L., Nepomnyashchikh A., 2017, *Monthly Notices of the RAS*, 470, 3124

- Kitchatinov L. L., Olemskoy S. V., 2010, *Astron. Lett.*, 36, 292
- Kitchatinov L. L., Olemskoy S. V., 2011, *Astronomy Letters*, 37, 656
- Kitchatinov L. L., Mordvinov A. V., Nepomnyashchikh A. A., 2018, *Astronomy and Astrophysics*, 615, A38
- Krause F., Rädler K. H., 1980, *Mean-field magnetohydrodynamics and dynamo theory*. Oxford: Pergamon Press
- Kumar P., Nagy M., Lemerle A., Karak B. B., Petrovay K., 2021a, *Astrophysical Journal*, 909, 87
- Kumar P., Karak B. B., Vashishth V., 2021b, *Astrophysical Journal*, 913, 65
- Kumar P., Biswas A., Karak B. B., 2022, *Monthly Notices of the RAS*, 513, L112
- Labonville F., Charbonneau P., Lemerle A., 2019, *Solar Physics*, 294, 82
- Leighton R. B., 1964, *Astrophysical Journal*, 140, 1547
- Leighton R. B., 1969, *Astrophysical Journal*, 156, 1
- Lemerle A., Charbonneau P., 2017, *Astrophysical Journal*, 834, 133
- Lemerle A., Charbonneau P., Carignan-Dugas A., 2015a, *Astrophysical Journal*, 810, 78
- Lemerle A., Charbonneau P., Carignan-Dugas A., 2015b, *The Astrophysical Journal*, 810, 78
- Makarov V. I., Fatianov M. P., Sivaraman K. R., 1983, *Solar Physics*, 85, 215
- Makarov V. I., Makarova V. V., Sivaraman K. R., 1989, *Solar Physics*, 119, 45
- Makarov V. I., Tlatov A. G., Callebaut D. K., Obridko V. N., Shelting B. D., 2001, *Solar Physics*, 198, 409
- Mandal S., Karak B. B., Banerjee D., 2017, *Astrophysical Journal*, 851, 70
- Martin-Belda D., Cameron R. H., 2017, *Astronomy and Astrophysics*, 597, A21
- McClintock B. H., Norton A. A., 2016, *Astrophysical Journal*, 818, 7
- McClintock B. H., Norton A. A., Li J., 2014, *Astrophysical Journal*, 797, 130
- Metcalfe T. S., Egeland R., van Saders J., 2016, *Astrophysical Journal, Letters*, 826, L2
- Miesch M. S., Dikpati M., 2014, *Astrophysical Journal, Letters*, 785, L8
- Miesch M. S., Teweldebirhan K., 2016, *Space Science Reviews*,
- Miesch M. S., Featherstone N. A., Rempel M., Trampedach R., 2012, *Astrophysical Journal*, 757, 128

- Moffatt H. K., 1978, Magnetic field generation in electrically conducting fluids
- Mordvinov A. V., Karak B. B., Banerjee D., Chatterjee S., Golubeva E. M., Khlystova A. I., 2020, *The Astrophysical Journal Letters*, 902, L15
- Mordvinov A. V., Karak B. B., Banerjee D., Golubeva E. M., Khlystova A. I., Zhukova A. V., Kumar P., 2022, *Monthly Notices of the RAS*, 510, 1331
- Muñoz-Jaramillo A., Nandy D., Martens P. C. H., Yeates A. R., 2010, *Astrophysical Journal, Letters*, 720, L20
- Muñoz-Jaramillo A., Nandy D., Martens P. C. H., 2011, *Astrophysical Journal, Letters*, 727, L23
- Muñoz-Jaramillo A., Sheeley N. R., Zhang J., DeLuca E. E., 2012, *Astrophysical Journal*, 753, 146
- Muñoz-Jaramillo A., Dasi-Espuig M., Balmaceda L. A., DeLuca E. E., 2013, *Astrophysical Journal, Letters*, 767, L25
- Nagy M., Lemerle A., Labonville F., Petrovay K., Charbonneau P., 2017, *Solar Physics*, 292, 167
- Nandy D., 2021, *Solar Physics*, 296, 54
- Nandy D., Choudhuri A. R., 2002, *Science*, 296, 1671
- Norton A., Howe R., Upton L., Usoskin I., 2023, arXiv e-prints, p. arXiv:2305.19803
- Pal S., Bhowmik P., Mahajan S. S., Nandy D., 2023, arXiv e-prints, p. arXiv:2305.13145
- Parker E. N., 1955a, *Astrophysical Journal*, 121, 491
- Parker E. N., 1955b, *Astrophysical Journal*, 122, 293
- Parker E. N., 1975, *Astrophysical Journal*, 198, 205
- Pesnell W. D., 2012, *Solar Physics*, 281, 507
- Pesnell W. D., Schatten K. H., 2018, *Solar Physics*, 293, 112
- Petrie G. J. D., 2015, *Living Reviews in Solar Physics*, 12, 5
- Petrovay K., 2020, *Living Reviews in Solar Physics*, 17, 2
- Petrovay K., Talafha M., 2019, *Astronomy and Astrophysics*, 632, A87
- Petrovay K., Nagy M., Gerják T., Juhász L., 2018, *Journal of Atmospheric and Solar-Terrestrial Physics*, 176, 15
- Petrovay K., Nagy M., Yeates A. R., 2020, *Journal of Space Weather and Space Climate*, 10, 50
- Pipin V. V., Kosovichev A. G., 2011, *Astrophysical Journal*, 741, 1

- Pipin V. V., Sokoloff D. D., 2011, *Physica Scripta*, 84, 065903
- Priyal M., Banerjee D., Karak B. B., Muñoz-Jaramillo A., Ravindra B., Choudhuri A. R., Singh J., 2014, *Astrophysical Journal, Letters*, 793, L4
- Rajaguru S. P., Antia H. M., 2015, *Astrophysical Journal*, 813, 114
- Reinhold T., Gizon L., 2015, *Astronomy and Astrophysics*, 583, A65
- Rengarajan T. N., 1984, *Astrophysical Journal, Letters*, 283, L63
- Rieger E., Share G. H., Forrest D. J., Kanbach G., Reppin C., Chupp E. L., 1984, *Nature*, 312, 623
- Schatten K. H., Scherrer P. H., Svalgaard L., Wilcox J. M., 1978, *Geophysics Research Letters*, 5, 411
- Schou J., et al., 1998, *Astrophysical Journal*, 505, 390
- Sheeley N. R. J., 1966, *Astrophysical Journal*, 144, 723
- Sheeley N. R. J., 1991, *Astrophysical Journal*, 374, 386
- Sivaraman K. R., Gokhale M. H., Sivaraman H., Gupta S. S., Howard R. F., 2007, *Astrophysical Journal*, 657, 592
- Skumanich A., 1972, *Astrophysical Journal*, 171, 565
- Solanki S. K., Usoskin I. G., Kromer B., Schüssler M., Beer J., 2004, *Nature*, 431, 1084
- Solanki S. K., Wenzler T., Schmitt D., 2008, *Astronomy and Astrophysics*, 483, 623
- Sreedevi A., Jha B. K., Karak B. B., Banerjee D., 2023, arXiv e-prints, p. arXiv:2304.06615
- Steenbeck M., Krause F., 1969, *Astronomische Nachrichten*, 291, 49
- Steenbeck M., Krause F., Rädler K. H., 1966, *Zeitschrift Naturforschung Teil A*, 21, 369
- Stenflo J. O., 2012, *Astronomy and Astrophysics*, 547, A93
- Stenflo J. O., Kosovichev A. G., 2012, *Astrophysical Journal*, 745, 129
- Svalgaard L., Duvall T. L. J., Scherrer P. H., 1978, *Solar Physics*, 58, 225
- Takalo J., 2023, *Solar Physics*, 298, 86
- Temmer M., 2021, *Living Reviews in Solar Physics*, 18, 4
- Tlatov A. G., 2023, *Solar Physics*, 298, 93
- Traversi R., Usoskin I., Solanki S. K., Becagli S., Frezzotti M., Severi M., Stenni B., Udisti R., 2012, in 39th COSPAR Scientific Assembly. p. 2001
- Upton L. A., Hathaway D. H., 2018, *Geophysics Research Letters*, 45, 8091

- Upton L., Coddington O., Kopp G., Lean J., 2021, in American Astronomical Society Meeting Abstracts. p. 304.07
- Usoskin I. G., 2023, Living Reviews in Solar Physics, 20, 2
- Verdell T., 2021, in AGU Fall Meeting Abstracts. pp ED45B–0721
- Waldmeier M., 1935, Astronomische Mitteilungen der Eidgenössischen Sternwarte Zurich, 14, 105
- Waldmeier M., 1955, Ergebnisse und Probleme der Sonnenforschung.
- Wang Y.-M., Sheeley Jr. N. R., 1989, Solar Physics, 124, 81
- Wang Y.-M., Sheeley N. R., 2009, Astrophysical Journal, Letters, 694, L11
- Wang Y.-M., Colaninno R. C., Baranyi T., Li J., 2015, Astrophysical Journal, 798, 50
- Wilmot-Smith A. L., Nandy D., Hornig G., Martens P. C. H., 2006, Astrophysical Journal, 652, 696
- Wolf R., 1848, Nachrichten von der Sternwarte in Bern, doi:10.3931/e-rara-2007.
- Xiang N. B., Qu Z. N., Zhai Q., 2014, Astronomical Journal, 148, 12
- Yeates A. R., Muñoz-Jaramillo A., 2013, Monthly Notices of the RAS, 436, 3366
- Yeates A. R., Nandy D., Mackay D. H., 2008, Astrophysical Journal, 673, 544
- Yoshimura H., 1975, Astrophysical Journal, 201, 740
- Zhukova A., Khlystova A., Abramenko V., Sokoloff D., 2022, Monthly Notices of the RAS,
- Zilli Vieira C. L., Alvares D., Huang S., Schwartz J., Coull B., Koutrakis P., 2019, in AGU Fall Meeting Abstracts. pp GP22A–02
- de Haro Barbás B. F., Elias A. G., Venchiarutti J. V., Fagre M., Zossi B. S., Tan Jun G., Medina F. D., 2021, Pure and Applied Geophysics, 178, 4605