Review of Scaling, dynamical régimes and stratification: How long does weather last? How big is a cloud? S. Lovejoy

GENERAL

I regard this paper as a *tour de force*, well worthy of publication in *NPG*. However, there it would have an element of preaching to the choir. The message really needs to be put in front of the core atmospheric science and climate readership, whose reluctance to embrace new thinking is one of the targets of the paper. *JAS, MWR, QJRMS, Climatic Change, Revs Geophys, npj-Climate and Atmospheric Science* are all possibilities immediately coming to mind. Not all of course might accommodate 150 pages.

SL: Thanks for the encouragement! It may be that the NPG venue is not the most appropriate, but at least – since it is open access - this may not make so much difference anymore. And there is the need for another book.

COMMENTARY

Line

49: the month is based on the (current) 29.7-day period of the moon's orbit around Earth. I agree the calendar as widely used wavers between 28 and 31.

SL: Thanks, I clarified that!

83: the dissipation time has been argued to be on molecular scales, much shorter than millimetric or millisecond - scales which reflect the resolution of observational instruments. See https://doi.org/10.3390/meteorology1010003. Dissipation is radiation of IR photons to space. Does OLR scale? It should.

SL: Thanks for the reference, I added the information and the reference to the text.

98: Include scales upward from the mean free path at STP and even more can be added. Maxwell-Boltzmann volumes of gas do not exist in the atmosphere - their continuous translational symmetry is broken by persistence of molecular velocity after collision.

SL: The figure caption does not make reference to the dissipation scale, only the range of scales visible in the image.

128: Virtually all quantitative images of clouds are two dimensional, or one-dimensional slices. How can three dimensional variability be addressed? Or should it be 23/9 D?

SL: I try to address this in the sections that follow, especially section 4.

164: I guess that answers my question at line 128.

SL: Yes.

187: "doe"? Reproduced or
Adapted?

SL: Adapted, thanks.

195:row.
SL: Thanks.

212:'expert judgement' should be referenced - and viewed sceptically given the nonlinearity of the system being dealt with.

SL: Conventionally here, the nonlinearity is taken into account by the "climate feedback" parameter, the inverse of the climate sensitivity. To some degree of approximation, the temperature response of the earth to a small perturbation is linear (anthropogenic forcing is of the order of 2.5W/m^2 compared to an average (absorbed) solar radiation of 240 W/m^2.

223: the average scale height is 7.4 km
SL: OK.

228: cite Lovejoy et al, *GRL*, **34,** L15802 (2007)
SL: OK, thanks!

238-9: 'This review" reads ambiguously to me. It is clearly not the current paper, but nor is it Lovejoy (2019).

SL: Thanks, I added “the present review”

243: developed.

SL: Thanks.

262: suggest colon after covered.
SL: Thanks.

286-8: this sentence needs punctuation.
SL: Thanks.

312: but the variance doesn't converge! (1.5<α<2).

SL: The variance of the generator (the log) of the process doesn’t converge, but the variance of the process itself will generally (but not necessarily) converge.

338: See Kadau et al, *Phil Trans Roy Soc A* **368,** 1547-1560 (2010). Also see above comments on 'millimetric' and dissipation.

SL: Thanks for the reference, I have included this and a few to Tuck’s work.

359: wasn't it the turbulent Loch Lomond?

SL: Thanks we were both almost right, it was a pier (not a bridge) and it was Loch Long not Loch Lomond!

429 et seq: Heisenberg, von Weiszäcker, Onsager all got the same result as Kolmogorov's 1941 paper but did so immediately after WW2 and in ignorance of Kolmogorov's paper. Landau criticised Kolmogorov in 1944 for ignoring intermittency. As a matter of historical interest, Heisenberg did his doctorate for Sommerfeld and Wien at Munchen on the transition from laminar to turbulent flow. Sommerfeld wanted to pass him with a high grade, but Wien wanted to fail him. A compromise was reached, and Heisenberg got his doctorate with the lowest grade of pass. He then left for Born at Gottingen on the grounds that turbulence was too difficult - with well-known results.

SL: Thanks. Some of this is in my 2019 book, ch. 4.

525-538: Figure 13 is very telling. As is Figure 14. Personally, I think Ghil's recent approach is inexcusable. NOAA has even less excuse.

SL: Yes!

667-668: Eliminate one of the "to's"

SL: Thanks.

788-792: Is it not Lagrangian sampling of Eulerian GCM-based analyses?

SL: I added the part in parentheses: “these space time diagrams are Lagrangian (albeit deduced from Eulerian data and reanalyses).”

801: 'Galilean' - and elsewhere.

SL: Thanks.

821-822: Grammar needs revision.

SL: Thanks.

904: Lévy - and elsewhere.

SL: Thanks.

918: no apostrophe in the possessive its.

SL: Thanks.

1066-1076: Specify units of L_{eff} in either Table 1 or its caption.
SL: Thanks.

1069: Several typos here. 'intermittency', alpha not a, exponent.
SL: Thanks.

1152: Reynolds' not Reynold's.
SL: Thanks.

1174: typo - reflectivity factor
SL: Thanks.

1298: 'estimates' not 'estates'?
SL: Thanks.

1304: Reynolds'
SL: Thanks.

1322: is the probability.....?

SL: Thanks.

1379: 'special'
SL: Thanks.

1450: Hovde et al, *Int. J. Remote Sensing* **32,** 5891-5918 (2011) and https://doi.org/10.3390/atmos12111414 might add to this data and section.

SL: Added in several places, thanks.

1546: its not it's
SL: Thanks.

1712: test is to consider.....
SL: Thanks.

1723-1730: This argument belongs in the text rather than the figure caption. Dynamical meteorologists obeying 23/9 scaling, however inadvertently, is worth more prominence.

SL: Yes, good idea, I modified the text and caption accordingly.

1768: 10^9
SL: Thanks.

1772: 55 great circle degrees?

SL: This plot is in flat space, so usual angles!

1815 et eq: Outgoing IR radiation is critically affected by clouds. Have OLR fields been examined for scaling?

SL: Yes, from IR imagery, for example as analysed in fig. 8, 25, 26.

1855-6: it's black and white in what I downloaded. Also 1865-6.

SL: Thanks.

1888: English needs amendment.

SL: Thanks.

1944 et seq: A Maxwell-Boltzmann (equilibrated) gas has continuous translational symmetry. It is broken at molecular and photon scales, see https://doi.org/10.3390/meteorology1010003

SL: Thanks.

1966: scale height is 7.4 km

SL: Thanks. I put "≈" in front of it: only the order of magnitude is important here.