



Working with Unspecified, Approximate, Uncertain, Sets and Ranges of Dates with **messydates**

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Abstract

This paper presents the **messydates** package for R, which facilitates working with ‘messy’ dates. Messy dates are common when studying historical and sometimes even current phenomena, and can create various technical problems for the data analyst. The paper highlights these problems and offers practical advice on how to solve them using **messydates**. The paper also introduces a conceptual framework for resolving messydates into more familiar date classes in R ready for analysis.

Keywords: dates, ISO, R.

1. Introduction

Dates are often messy. Whether historical (or ancient), future, or even recent, we often only know approximately when an event occurred, that it happened within a particular period, an unreliable source means a date should be flagged as uncertain, or sources offer multiple, competing dates.

messydates implements the extended annotation standard for dates, the Extended Date/Time Format (EDTF), outlined in [ISO 8601-2_2019\(E\)](#) for R. These include standardised notation for:

- unspecified date(component)s, e.g. 2012-XX-01 for the first of some unknown month in 2012 or 2012-01 for some unknown day in January 2012
- approximate date(component)s, e.g. 2012-01-12~ for approximately the 12th of January 2012

- messydates** contains a set of tools for constructing and coercing into and from the `mdate` class. This date class allows regular dates to be annotated to express unspecified date components, approximate or uncertain date components, date ranges, and sets of dates.

1.1. Motivation

1.2. Relationship to other packages

2. R code

messydates contains a set of tools for constructing and coercing into and from the **mdate** class. This date class implements ISO 8601-2:2019(E) and allows regular dates to be annotated to express unspecified date components, approximate or uncertain date components, date ranges, and sets of dates. The function `as_messydate()` handles the coercion to **mdate** class.

[illegible]

```

+           "A written date", "First of February, two thousand a
+           "A historical date", "476",
+           "An era date", "33 BC",
+           "An approximate date", "2012-01-12~",
+           "An uncertain date", "2001-01-01?",
+           "An unspecified date", "2012-01",
+           "A censored date", "..2012-01-12",
+           "A range of dates", "2019-11-01:2020-01-01",
+           "A set of dates", "2021-5-26, 2021-11-19, 2021-12-4"
+   dplyr::mutate(base = as.Date(OriginalDate),
+                 lubridate = lubridate::as_date(OriginalDate),
+                 anytime = anytime::anydate(OriginalDate),
+                 messydates = messydates::as_messydate(OriginalDate)) %>%
+   print()

# A tibble: 11 x 6
  Example      OriginalDate base      lubridate anytime      messydates
  <chr>        <chr>      <date>    <date>    <date>    <mdate>
1 A normal date 2022-07-06 2022-07-06 2022-07-06 2022-07-06 2022-07-0~
2 A future date 2599-12-31 2599-12-31 2599-12-31 2599-12-31 2599-12-3~
3 A written date First of Feb~ NA        NA        NA        2021-02-0~
4 A historical date 476      NA        NA        NA        0476      ~
5 An era date   33 BC    NA        NA        NA        -0033     ~
6 An approximate date 2012-01-12~ 2012-01-12 2012-01-12 2012-01-12 2012-01-1~
7 An uncertain date 2001-01-01? 2001-01-01 2001-01-01 2001-01-01 2001-01-0~
8 An unspecified date 2012-01    NA        2020-12-01 2012-01-01 2012-01    ~
9 A censored date ..2012-01-12 NA        2012-01-12 NA        ..2012-01~
10 A range of dates 2019-11-01:2~ 2019-11-01 2019-11-01 2019-11-01 2019-11-0~
11 A set of dates 2021-5-26, 2~ 2021-05-26 NA        2021-05-26 {2021-05--~

```

2.2. Annotate

Some datasets have, for example, an arbitrary cut off point for start and end points, but these are often coded as precise dates when they are not necessarily the real start or end dates. The `annotate` functions help annotate uncertainty and approximation to dates. Inaccurate start or end dates can be represented by an affix indicating “on or before”, if used as a prefix (e.g. `..1816-01-01`), or indicating “on or after”, if used as a suffix (e.g. `2016-12-31..`). Approximate dates are indicated by adding a `~` to year, month, or day components, as well as groups of components or whole dates to estimate values that are possibly correct (e.g. `2003-03-03~`). Day, month, or year, uncertainty can be indicated by adding a `?` to a possibly dubious date (e.g. `1916-10-10?`) or date component (e.g. `1916-?10-10`).

```

R> dates_annotate <- tibble::tibble(Beg = as_messydate(c("1816-01-01", "1916-01-01", "2016-
+                               End = as_messydate(c("1816-12-31", "1916-12-31", "2016-
+   dplyr::mutate(on_or_before = ifelse(Beg <= "1816-01-01", on_or_before(Beg), Beg),
+   on_or_after = ifelse(End >= "2016-01-01", on_or_after(End), End),

```

```
+           as_approximate = ifelse(End >= "2016-01-01", on_or_after(End), End),
+           as_uncertain = ifelse(End == "1916-12-31", as_uncertain(End), End)) %>%
+   print()
```

```
# A tibble: 3 x 6
```

	Beg <mdate>	End <mdate>	on_or_before <chr>	on_or_after <chr>	as_approximate <chr>	as_uncertain <chr>
1	1816-01-01	1816-12-31	..1816-01-01	1816-12-31	1816-12-31	1816-12-31
2	1916-01-01	1916-12-31	1916-01-01	1916-12-31	1916-12-31	1916-12-31?
3	2016-01-01	2016-12-31	2016-01-01	2016-12-31..	2016-12-31..	2016-12-31

2.3. Expand

Expand functions transform date ranges, sets of dates, and unspecified or approximate dates (annotated with ‘.’, ‘{ , }’, ‘XX’ or ‘~’) into lists of dates. As these dates may refer to several possible dates, the function “opens” these values to include all the possible dates implied.

```
R> dates_expand <- as_messydate(c("2001-01-01", "2001-01", "2001-01-01..2001-02-01",
+                                "{2001-01-01,2001-02-01}", "2001-XX-01"))
R> expand(dates_expand)
```

```
[[1]]
```

```
[1] "2001-01-01"
```

```
[[2]]
```

```
[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[6] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[16] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
[21] "2001-01-21" "2001-01-22" "2001-01-23" "2001-01-24" "2001-01-25"
[26] "2001-01-26" "2001-01-27" "2001-01-28" "2001-01-29" "2001-01-30"
[31] "2001-01-31"
```

```
[[3]]
```

```
[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[6] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[16] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
[21] "2001-01-21" "2001-01-22" "2001-01-23" "2001-01-24" "2001-01-25"
[26] "2001-01-26" "2001-01-27" "2001-01-28" "2001-01-29" "2001-01-30"
[31] "2001-01-31" "2001-02-01"
```

```
[[4]]
```

```
[1] "2001-01-01" "2001-02-01"
```

```
[[5]]
```

```
[1] "2001-01-01" "2001-02-01" "2001-03-01" "2001-04-01" "2001-05-01"
[6] "2001-06-01" "2001-07-01" "2001-08-01" "2001-09-01" "2001-10-01"
[11] "2001-11-01" "2001-12-01"
```

2.4. Contract

The `contract()` function operates as the opposite of `expand()`. It contracts a list of dates into the abbreviated annotation of **messydates**.

```
R> tibble::tibble(contract = contract(expand(dates_expand)))

# A tibble: 5 x 1
  contract
  <mdate>
1 2001-01-01
2 2001-01
3 2001-01-01..2001-02-01
4 {2001-01-01,2001-02-01}
5 2001-XX-01
```

2.5. Coerce from messydates

Coercion functions coerce objects of `mdate` class to common date classes such as `Date`, `POSIXct`, and `POSIXlt`. Since `mdate` objects can hold multiple individual dates, an additional function must be passed as an argument so that multiple dates are “resolved” into a single date.

For example, one might wish to use the earliest possible date in any ranges of dates (`min`), the latest possible date (`max`), some notion of a central tendency (`mean`, `median`, or `modal`), or even a `random` selection from amongst the candidate dates.

These functions are particularly useful for use with existing methods and models, especially for checking the robustness of results.

```
R> tibble::tibble(min = as.Date(dates_expand, min),
+                 max = as.Date(dates_expand, max),
+                 median = as.Date(dates_expand, median),
+                 mean = as.Date(dates_expand, mean),
+                 modal = as.Date(dates_expand, modal),
+                 random = as.Date(dates_expand, random))

# A tibble: 5 x 6
  min      max      median    mean    modal    random
  <date>   <date>   <date>   <date>   <date>   <date>
1 2001-01-01 2001-01-01 2001-01-01 2001-01-01 2001-01-01 2001-01-01
2 2001-01-01 2001-01-31 2001-01-16 2001-01-16 2001-01-01 2001-01-28
3 2001-01-01 2001-02-01 2001-01-17 2001-01-16 2001-01-01 2001-01-15
4 2001-01-01 2001-02-01 2001-02-01 2001-01-16 2001-01-01 2001-01-01
5 2001-01-01 2001-12-01 2001-07-01 2001-06-16 2001-01-01 2001-01-01
```

2.6. Additional functionality

Several other functions are also offered in the **messydates** package.

For example, one can check various logical tests for messy date objects. `is_messydate()` tests whether the object inherits the `mdate` class. `is_intersecting()` tests whether there is any intersection between two messy dates. `is_element()` similarly tests whether a messy date can be found within a messy date range or set. `is_similar()` tests whether two dates contain similar components. `is_precise()` tests for whether date is precise.

```
R> is_messydate(as_messydate("2001-01-01"))
```

```
[1] TRUE
```

```
R> is_messydate(as.Date("2001-01-01"))
```

```
[1] FALSE
```

```
R> is_intersecting(as_messydate("2001-01"), as_messydate("2001-01-01..2001-02-22"))
```

```
[1] TRUE
```

```
R> is_intersecting(as_messydate("2001-01"), as_messydate("2001-02-01..2001-02-22"))
```

```
[1] FALSE
```

```
R> is_element(as_messydate("2001-01-01"), as_messydate("2001-01"))
```

```
[1] TRUE
```

```
R> is_element(as_messydate("2001-01-01"), as_messydate("2001-02"))
```

```
[1] FALSE
```

```
R> is_similar(as_messydate("2001-06-02"), as_messydate("2001-02-06"))
```

```
[1] TRUE
```

```
R> is_similar(as_messydate("2001-06-22"), as_messydate("2001-02-06"))
```

```
[1] FALSE
```

```
R> is_precise(as_messydate("2001-06-02"))
```

```
[1] TRUE
```

```
R> is_precise(as_messydate("2001-02"))
```

```
[1] FALSE
```

Additionally, one can perform intersection (`md_intersect()`) and union (`md_union()`) on, inter alia, messy date class objects. Or ‘join’ that retains all elements, even if duplicated, with `md_multiset`.

```
R> md_intersect(as_messydate("2001-01-01..2001-01-20"),as_messydate("2001-01"))
```

```
[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[6] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[16] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
```

```
R> md_union(as_messydate("2001-01-01..2001-01-20"),as_messydate("2001-01"))
```

```
[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[6] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[16] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
[21] "2001-01-21" "2001-01-22" "2001-01-23" "2001-01-24" "2001-01-25"
[26] "2001-01-26" "2001-01-27" "2001-01-28" "2001-01-29" "2001-01-30"
[31] "2001-01-31"
```

```
R> md_multiset(as_messydate("2001-01-01..2001-01-20"),as_messydate("2001-01"))
```

```
[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[6] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[16] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
[21] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
[26] "2001-01-06" "2001-01-07" "2001-01-08" "2001-01-09" "2001-01-10"
[31] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
[36] "2001-01-16" "2001-01-17" "2001-01-18" "2001-01-19" "2001-01-20"
[41] "2001-01-21" "2001-01-22" "2001-01-23" "2001-01-24" "2001-01-25"
[46] "2001-01-26" "2001-01-27" "2001-01-28" "2001-01-29" "2001-01-30"
[51] "2001-01-31"
```

As well, some arithmetic operations are available for messydates. For instance, one can add or subtract one year to all messy dates in a vector.

```
R> tibble::tibble(date = dates_expand, add = dates_expand + "1 day", subtract = dates_exp
```

```
# A tibble: 5 x 3
```

	date	add	subtract
	<mdate>	<mdate>	<mdate>
1	2001-01-01	2001-01-02	2000-01-02

```

2 2001-01                2001-01-02..2001-02-01  2000-01-02..2000-02-01
3 2001-01-01..2001-02-01  2001-01-02..2001-02-02  2000-01-02..2000-02-02
4 {2001-01-01,2001-02-01} {2001-01-02,2001-02-02} {2000-01-02,2000-02-02}
5 2001-XX-01            2001-XX-02            2000-XX-02

```

2.7. Case Study - 2001 Battles

Dates, even for some recent events, can be messy. Take the dates of battles in 2001 according to [Wikipedia](#) included in **messydates**. The dates of these battles are often approximate (i.e. the day in which a battle started or ended is not precise) or come from unreliable sources (i.e. the date is precise but not trustworthy).

```

R> battles <- messydates::battles
R> battles

```

```
# A tibble: 20 x 3
```

Battle <chr>	Date <mdate>	Parties <chr>
1 Operation MH-2	2001-03-08	MK-National Li~
2 2001 Bangladesh-India border clashes	2001-04-16..2001-04-20	BD-ID
3 Operation Vaksince	2001-05-25	MK-National Li~
4 Alkhan-Kala operation	2001-06-22..2001-06-28	RU-Chechen Rep~
5 Battle of Vedenov	2001-08-13..2001-08-26	RU-Chechen Ins~
6 Operation Crescent Wind	2001-10-7..2001-12?	US/UK-Taliban
7 Operation Rhino	2001-10-19..2001-10-20	US-Taliban
8 Battle of Mazar-e-Sharif	2001-11-09	US/Northern Al~
9 Siege of Kunduz	2001-11-11..2001-11-23	US/Northern Al~
10 Battle of Herat	2001-11-12	US/Northern Al~
11 Battle of Kabul	2001-11-13..2001-11-14	US/Northern Al~
12 Battle of Tarin Kowt	2001-11-13..2001-11-14	US/Eastern All~
13 Operation Trent	2001-11-~15..2001-11-~30	US/UK-Taliban/~
14 Battle of Kandahar	2001-11-22..2001-12-07	US/AU/Eastern ~
15 Battle of Qala-i-Jangi	2001-11-25..2001-12-01	US/UK/Northern~
16 Battle of Tora Bora	2001-12-12..2001-12-17	US/Northern Al~
17 Battle of Shawali Kowt	2001-12-03	US/Eastern All~
18 Battle of Sayyid Alma Kalay	2001-12-04	US/Eastern All~
19 Battle of Amami-Oshima	2001-12-22	JP-KP
20 Tsotsin-Yurt operation	2001-12-30..2002-01-03	RU-Chechen Ins~

messydates facilitates working with these dates as we can, for example, check which dates are precise, get the median values for imprecise dates and find the longest battle in 2001.

```
R> messydates::is_precise(battles$Date)
```

```

[1] TRUE FALSE TRUE FALSE FALSE FALSE FALSE TRUE FALSE TRUE FALSE FALSE
[13] FALSE FALSE FALSE FALSE TRUE TRUE TRUE FALSE

```



```
R> as.Date(battles$Date, median)
```

```
[1] "2001-03-08" "2001-04-18" "2001-05-25" "2001-06-25" "2001-08-20"
[6] "2001-11-19" "2001-10-20" "2001-11-09" "2001-11-17" "2001-11-12"
[11] "2001-11-14" "2001-11-14" "2001-11-23" "2001-11-30" "2001-11-28"
[16] "2001-12-15" "2001-12-03" "2001-12-04" "2001-12-22" "2002-01-01"
```

```
R> as.numeric(as.Date(battles$Date, max) - as.Date(battles$Date, min))
```

```
[1] 0 4 0 6 13 85 1 0 12 0 1 1 15 15 6 5 0 0 0 4
```

Getting the timing can be important for researchers, however, when faced with date imprecision, researchers usually have to choose between making arbitrary choices (e.g. adding “-01-01” to all incomplete dates) or work imprecise dates (e.g. keep the year only). Yet, both choices may lead to bias results. This is especially true if researchers’ are looking to generate inferences. Let’s assume, for instance, certain researcher is interested in the relationship between the United States (US) being a party to a conflict and the duration of the conflict in 2001. The researcher theorizes that conflicts involving the US have a shorter duration because the US has the most powerful military in the world. But this relationship could be mediated by the number of parties involved in the conflict. Using **messydates**, we can create two different date variables in the battles data to be our dependent variables representing conflict time, one variable with an arbitrary cut of point and the other variable with random values for uncertain or approximate dates. As our independent variable, we create a dummy variable for whether the US was involved in the conflict. As our control, we code the number of actors in the conflict. With these variables we build two linear regression models, one using the arbitrary dates and the other the random dates.

```
R> set.seed(1301)
R> battles <- battles %>%
+   mutate(arbitrary = as.numeric(as.Date(Date, max) - as.Date(Date, min)),
+         random = ifelse(grepl("\\?/\\~", Date),
+                         abs(as.Date(Date, random) - as.Date(Date, random)),
+                         arbitrary),
+         US_party = ifelse(grepl("US", Parties), 1, 0),
+         n_actors = c(2, 2, 2, 2, 2, 3, 2, 4, 4, 4, 3, 3, 4, 4, 5, 4, 3, 3, 2, 2))
R> lm(arbitrary ~ US_party + n_actors, battles)
```

Call:

```
lm(formula = arbitrary ~ US_party + n_actors, data = battles)
```

Coefficients:

(Intercept)	US_party	n_actors
8.815	10.802	-2.479

```
R> lm(random ~ US_party + n_actors, battles)
```

Call:

```
lm(formula = random ~ US_party + n_actors, data = battles)
```

Coefficients:

(Intercept)	US_party	n_actors
0.538	-1.410	1.660

Notice how the regression coefficients change when we pick random values within the range for the uncertain and approximate dates in the battles data, in comparison to setting arbitrary cut off points. Although not statistically significant, the coefficient for US being a party in a conflict change considerably, going from being positive to becoming negative, when we use random values within that range. In this case, it is hard to say whether there is a relationship between the US being a part of a battle in 2001 and the time of the conflict.

3. Acknowledgements

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References

Eddelbuettel D (2019). “Anytime: Easier Date and Time Conversion.” p. 4.

Grolemund G, Wickham H (2011). “Dates and Times Made Easy with Lubridate.” **40**(3), 1–25. ISSN 1548-7660. doi:10.18637/jss.v040.i03. URL <http://www.jstatsoft.org/v40/i03/>.

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