



## Working with Missing, 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.

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## 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.

As researchers, we often recognise this messiness but are forced to force non-existent precision on data so we can proceed with analysis. For example, if we only know something happened in a given month or year, we might just opt for the start of that month (e.g. 2021-07-01) or year (2021-01-01), assuming that to err on the earlier (or later) side is a justifiable bias. However, this can create issues for inference in which sequence or timing is important. The goal of **messydates** is to help with this problem by retaining and working with various kinds of date imprecision.

### 1.1. A quick overview

**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
- uncertain date( component)s, e.g. 2012-01-12? where this data point is based on an unreliable source
- sets of dates, e.g. {2012-01-01,2012-01-12} where the date can be both 1 January 2012 and 12 January 2012
- ranges of dates, e.g. 2012-01-01..2012-01-12 for all dates between the 1 January 2012 and 12 January 2012 inclusive

**messydates** contains a set of tools for constructing and coercing into and from the **messydt** 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.

Importantly, the package also includes a function for unpacking or expanding sets or ranges of dates into all dates consistent with how the date or set of dates is specified or annotated. Methods are also offered that can be used to make explicit how researchers convert date imprecision into precise dates for analysis, such as getting the `min()`, `max()`, or even a `random()` date from among the dates consistent with a set or range of dates. This greatly facilitates research transparency as well as robustness checks.

## 1.2. Relationship to other packages

**messydates** offers a new date class, but one that comes with methods for converting from and into common date classes such as `Date`, `POSIXct`, and `POSIXlt`. It is thus fully compatible with packages such as **lubridate** ([Grolemund and Wickham 2011](#)) and **anytime** ([Eddelbuettel 2019](#)). It is also compatible with **unstruwwel**, which also parses historic dates in R, though the emphasis of our package is on working with these dates.

## 2. R code

### 2.1. A new class

**messydates** contains a set of tools for constructing and coercing into and from the **messydt** 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 **messydt** class.

```
R> library(messydates)
R> suppressPackageStartupMessages(library(lubridate))
R> library(tibble)
```

```
R> suppressPackageStartupMessages(library(dplyr))
R> dates_comparison <- tibble::tribble(~Example, ~OriginalDate,
+                                     "Normal date", "2010-01-01",
+                                     "Historical date", "1291-08-01",
+                                     "Very historical date", "476",
+                                     "Really historical date", "33 BC",
+                                     "Clearly future date", "9999-12-31",
+                                     "Not so clearly future date", "2599-12-31",
+                                     "Range of dates", "2019-11-01:2020-01-01",
+                                     "Uncertain date", "2001-01-01?",
+                                     "Set of dates", "2021-5-26, 2021-6-10, 2021-11-19, 2021-12-31",
R> dates_comparison %>% dplyr::mutate(base = as.Date(OriginalDate),
+                                     lubridate = suppressWarnings(lubridate::as_date(OriginalDate)),
+                                     messydates = messydates::as_messydate(OriginalDate))
+   print()
```

```
# A tibble: 9 x 5
```

Example	OriginalDate	base	lubridate	messydates
<chr>	<chr>	<date>	<date>	<messydt>
1 Normal date	2010-01-01	2010-01-01	2010-01-01	2010-01-0~
2 Historical date	1291-08-01	1291-08-01	1291-08-01	1291-08-0~
3 Very historical date	476	NA	NA	0476 ~
4 Really historical date	33 BC	NA	NA	-0033 ~
5 Clearly future date	9999-12-31	9999-12-31	9999-12-31	9999-12-3~
6 Not so clearly future date	2599-12-31	2599-12-31	2599-12-31	2599-12-3~
7 Range of dates	2019-11-01:2020-0~	2019-11-01	2019-11-01	2019-11-0~
8 Uncertain date	2001-01-01?	2001-01-01	2001-01-01	2001-01-0~
9 Set of dates	2021-5-26, 2021-6~	2021-05-26	NA	2021-05-2~

## 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", "2016-01-01")),
+                                   End = as_messydate(c("1816-12-31", "1916-12-31", "2016-12-31")),
+                                   year = c(1816, 1916, 2016))
R> dplyr::mutate(dates_annotate, Beg = ifelse(Beg <= "1816-01-01", on or before(Beg), Beg))
```

```
# A tibble: 3 x 2
  Beg      End
```

```

      <chr>          <messydt>
1 ..1816-01-01 1816-12-31
2 1916-01-01    1916-12-31
3 2016-01-01    2016-12-31

```

```
R> dplyr::mutate(dates_annotate, End = ifelse(End >= "2016-01-01", on_or_after(End), End))
```

```

# A tibble: 3 x 2
  Beg      End
  <messydt> <chr>
1 1816-01-01 1816-12-31
2 1916-01-01 1916-12-31
3 2016-01-01 2016-12-31..

```

```
R> dplyr::mutate(dates_annotate, Beg = ifelse(Beg == "1916-01-01", as_approximate(Beg), Beg))
```

```

# A tibble: 3 x 2
  Beg      End
  <chr>    <messydt>
1 1816-01-01 1816-12-31
2 1916-01-01~ 1916-12-31
3 2016-01-01 2016-12-31

```

```
R> dplyr::mutate(dates_annotate, End = ifelse(End == "1916-12-31", as_uncertain(End), End))
```

```

# A tibble: 3 x 2
  Beg      End
  <messydt> <chr>
1 1816-01-01 1816-12-31
2 1916-01-01 1916-12-31?
3 2016-01-01 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("2008-03-25", "2001-01?", "2001",
+                                "2001-01-01..2001-02-02", "{2001-01-01,2001-02-02}",
+                                "2008-XX-31", "28 BC"))
R> expand(dates_expand)

[[1]]
[1] "2008-03-25"

```

[[2]]

```

[1] "2001-01-01" "2001-01-02" "2001-01-03" "2001-01-04" "2001-01-05"
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[11] "2001-01-11" "2001-01-12" "2001-01-13" "2001-01-14" "2001-01-15"
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[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]]

```

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[221] "-0028-08-08" "-0028-08-09" "-0028-08-10" "-0028-08-11" "-0028-08-12"
[226] "-0028-08-13" "-0028-08-14" "-0028-08-15" "-0028-08-16" "-0028-08-17"
[231] "-0028-08-18" "-0028-08-19" "-0028-08-20" "-0028-08-21" "-0028-08-22"
[236] "-0028-08-23" "-0028-08-24" "-0028-08-25" "-0028-08-26" "-0028-08-27"
[241] "-0028-08-28" "-0028-08-29" "-0028-08-30" "-0028-08-31" "-0028-09-01"
[246] "-0028-09-02" "-0028-09-03" "-0028-09-04" "-0028-09-05" "-0028-09-06"
[251] "-0028-09-07" "-0028-09-08" "-0028-09-09" "-0028-09-10" "-0028-09-11"
[256] "-0028-09-12" "-0028-09-13" "-0028-09-14" "-0028-09-15" "-0028-09-16"
[261] "-0028-09-17" "-0028-09-18" "-0028-09-19" "-0028-09-20" "-0028-09-21"
[266] "-0028-09-22" "-0028-09-23" "-0028-09-24" "-0028-09-25" "-0028-09-26"
[271] "-0028-09-27" "-0028-09-28" "-0028-09-29" "-0028-09-30" "-0028-10-01"
[276] "-0028-10-02" "-0028-10-03" "-0028-10-04" "-0028-10-05" "-0028-10-06"
[281] "-0028-10-07" "-0028-10-08" "-0028-10-09" "-0028-10-10" "-0028-10-11"
[286] "-0028-10-12" "-0028-10-13" "-0028-10-14" "-0028-10-15" "-0028-10-16"
[291] "-0028-10-17" "-0028-10-18" "-0028-10-19" "-0028-10-20" "-0028-10-21"
[296] "-0028-10-22" "-0028-10-23" "-0028-10-24" "-0028-10-25" "-0028-10-26"
[301] "-0028-10-27" "-0028-10-28" "-0028-10-29" "-0028-10-30" "-0028-10-31"
[306] "-0028-11-01" "-0028-11-02" "-0028-11-03" "-0028-11-04" "-0028-11-05"
[311] "-0028-11-06" "-0028-11-07" "-0028-11-08" "-0028-11-09" "-0028-11-10"
[316] "-0028-11-11" "-0028-11-12" "-0028-11-13" "-0028-11-14" "-0028-11-15"
[321] "-0028-11-16" "-0028-11-17" "-0028-11-18" "-0028-11-19" "-0028-11-20"
[326] "-0028-11-21" "-0028-11-22" "-0028-11-23" "-0028-11-24" "-0028-11-25"
[331] "-0028-11-26" "-0028-11-27" "-0028-11-28" "-0028-11-29" "-0028-11-30"
[336] "-0028-12-01" "-0028-12-02" "-0028-12-03" "-0028-12-04" "-0028-12-05"
[341] "-0028-12-06" "-0028-12-07" "-0028-12-08" "-0028-12-09" "-0028-12-10"
[346] "-0028-12-11" "-0028-12-12" "-0028-12-13" "-0028-12-14" "-0028-12-15"
[351] "-0028-12-16" "-0028-12-17" "-0028-12-18" "-0028-12-19" "-0028-12-20"
[356] "-0028-12-21" "-0028-12-22" "-0028-12-23" "-0028-12-24" "-0028-12-25"
[361] "-0028-12-26" "-0028-12-27" "-0028-12-28" "-0028-12-29" "-0028-12-30"
[366] "-0028-12-31"

```

## 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: 7 x 1
  contract
  <messydt>

```



```

1 2008-03-25 ~
2 2001-01 ~
3 2001 ~
4 2001-01-01..2001-02-02 ~
5 {2001-01-01,2001-02-02} ~
6 {2008-01-31,2008-02-28,2008-03-31,2008-04-30,2008-05-31,2008-06-30,2008-07-31~
7 -0028 ~

```

## 2.5. Coerce from messydates

Coercion functions coerce objects of `messydt` class to common date classes such as `Date`, `POSIXct`, and `POSIXlt`. Since `messydt` 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: 7 x 6
   min      max      median      mean      modal      random
  <date>  <date>    <date>    <date>    <date>    <date>
1 2008-03-25 2008-03-25 2008-03-25 2008-03-25 2008-03-25 2008-03-25
2 2001-01-01 2001-01-31 2001-01-16 2001-01-16 2001-01-01 2001-01-30
3 2001-01-01 2001-12-31 2001-07-02 2001-07-02 2001-01-01 2001-04-20
4 2001-01-01 2001-02-02 2001-01-17 2001-01-17 2001-01-01 2001-01-18
5 2001-01-01 2001-02-02 2001-02-02 2001-01-17 2001-01-01 2001-02-02
6 2008-01-31 2008-12-31 2008-07-31 2008-07-15 2008-01-31 2008-11-30
7 -028-01-01 -028-12-31 -028-07-02 -028-07-01 -028-01-01 -028-04-27

```

## 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 `messydt` 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.

```
R> is_messydate(as_messydate("2012-01-01"))
```

```
[1] TRUE
```

```
R> is_messydate(as.Date("2012-01-01"))
```

```
[1] FALSE
```

```
R> is_intersecting(as_messydate("2012-01"), as_messydate("2012-01-01..2012-02-22"))
```

```
[1] FALSE
```

```
R> is_intersecting(as_messydate("2012-01"), as_messydate("2012-02-01..2012-02-22"))
```

```
[1] FALSE
```

```
R> is_element(as_messydate("2012-01-01"), as_messydate("2012-01"))
```

```
[1] TRUE
```

```
R> is_element(as_messydate("2012-01-01"), as_messydate("2012-02"))
```

```
[1] FALSE
```

```
R> is_similar(as_messydate("2012-06-02"), as_messydate("2012-02-06"))
```

```
[1] TRUE
```

```
R> is_similar(as_messydate("2012-06-22"), as_messydate("2012-02-06"))
```

```
[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("2012-01-01..2012-01-20"), as_messydate("2012-01"))
```

```
[1] "2012-01-01" "2012-01-02" "2012-01-03" "2012-01-04" "2012-01-05"
[6] "2012-01-06" "2012-01-07" "2012-01-08" "2012-01-09" "2012-01-10"
[11] "2012-01-11" "2012-01-12" "2012-01-13" "2012-01-14" "2012-01-15"
[16] "2012-01-16" "2012-01-17" "2012-01-18" "2012-01-19" "2012-01-20"
```

```
R> md_union(as_messydate("2012-01-01..2012-01-20"), as_messydate("2012-01"))
```

```
[1] "2012-01-01" "2012-01-02" "2012-01-03" "2012-01-04" "2012-01-05"
[6] "2012-01-06" "2012-01-07" "2012-01-08" "2012-01-09" "2012-01-10"
[11] "2012-01-11" "2012-01-12" "2012-01-13" "2012-01-14" "2012-01-15"
[16] "2012-01-16" "2012-01-17" "2012-01-18" "2012-01-19" "2012-01-20"
[21] "2012-01-21" "2012-01-22" "2012-01-23" "2012-01-24" "2012-01-25"
[26] "2012-01-26" "2012-01-27" "2012-01-28" "2012-01-29" "2012-01-30"
[31] "2012-01-31"
```

```
R> md_multiset(as_messydate("2012-01-01..2012-01-20"),as_messydate("2012-01"))
```

```
[1] "2012-01-01" "2012-01-02" "2012-01-03" "2012-01-04" "2012-01-05"
[6] "2012-01-06" "2012-01-07" "2012-01-08" "2012-01-09" "2012-01-10"
[11] "2012-01-11" "2012-01-12" "2012-01-13" "2012-01-14" "2012-01-15"
[16] "2012-01-16" "2012-01-17" "2012-01-18" "2012-01-19" "2012-01-20"
[21] "2012-01-01" "2012-01-02" "2012-01-03" "2012-01-04" "2012-01-05"
[26] "2012-01-06" "2012-01-07" "2012-01-08" "2012-01-09" "2012-01-10"
[31] "2012-01-11" "2012-01-12" "2012-01-13" "2012-01-14" "2012-01-15"
[36] "2012-01-16" "2012-01-17" "2012-01-18" "2012-01-19" "2012-01-20"
[41] "2012-01-21" "2012-01-22" "2012-01-23" "2012-01-24" "2012-01-25"
[46] "2012-01-26" "2012-01-27" "2012-01-28" "2012-01-29" "2012-01-30"
[51] "2012-01-31"
```

### 3. Acknowledgements

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### References

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