Title

Supplementary material to "Atmospheric River Tracking Method Intercomparison Project (ARTMIP): Project Goals and Experimental Design"

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Publication Date

2018-01-09

DOI

10.5194/gmd-2017-295-supplement

Atmospheric River Tracking Method Intercomparison Project (ARTMIP): Project Goals and Experimental Design

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Supplemental Text

1 IVT-UCSD derived 3-hourly versus IVT-MERRA-provided 1hourly

Comparing the 1-h to 3-h MERRA-2 provided time-averaged data suggests that there are only very small differences between the two, meaning that there is little value added to using 1-h data. Figure S1 shows the difference between the average IVT magnitude for February 2017 computed with those two frequencies. Note the small magnitudes of the colorbar. However, comparing the time-averaged 3-h MERRA-2-provided IVT ($kg\ m^{-1}s^{-1}$) to the 3-h IVT computed by the UCSD group, there are more substantial discrepancies over regions of substantial topographical relief, as well as regions where the surface pressure is considerably different from 1000hPa. Supplemental Figure2 shows the same difference as Figure S1, but for these two datasets. In particular, the UCSD-provided data overestimates IVT over topographic highs and underestimates it by various amounts over ocean regions, most dramatically in tropical and subtropical regions. This is consistent with the vertical integrals being done on the model grid in the one case, and with interpolated values over a limited pressure range in the other. Because some of these differences could be the difference between a detection and a non-detection, it is imperative that all participants use the same dataset to create their 1980-2017 AR catalogues. Due to resource constraints, as a group, we are using the lower temporal resolution dataset provided by UCSD.

2 Data formats for ARTMIP Submissions

2.1 All Submissions

The output should take the form of a NetCDF4 file with filename formatted as follows. For the purposes of the one-month analysis of MERRA2 data, Reanalysis datasetshould be MERRA2and time frequency should be 3hourly. The dateis either a single day in the form YYYYMMDD or a range of dates in the form YYYYMMDD-YYYYMMDD.

```
<Reanalysis dataset>.ar_tag.<Algorithm>.<hourly/3hourly/6hourly/daily>.<Date(s)>.nc4
```

The structure of the NetCDF4 file should follow the following format, for an example algorithm entitled Namev1run on 3-hourly data. The time, lat, and lonvariables should be inherited directly from the MERRA2 dataset. The ar_binary_tag variable should be of type byte(an 8-bit integer) so as to limit the size of each submission. This variable should be 1 if an atmospheric river is detected at this grid point / time and 0 if no detection occurred. Any number of files can be provided, although we suggest one file per processed day.

```
ncdump -h MERRA2.ar_tag.Name_v1.3hourly.20170201.nc4
netcdf

MERRA2.ar_tag.Name_v1.3hourly.20170201 { dimensions:

    time = UNLIMITED ; // (8
    currently) lat = 361 ;

    lon = 576 ;
variables:
```

```
        double time(time) ;
            time:standard_name = "time"
            ; time:long_name = "time" ;

            time:units = "minutes since 2017-02-01
            00:00:00" ; time:calendar = "standard" ;

        double lat(lat) ;

            lat:standard_name =
            "latitude" ; lat:long_name =
            "latitude" ; lat:units =
            "degrees_north" ; lat:axis =
            "Y" ;

        double lon(lon) ;

            lon:standard_name =
            "longitude" ; lon:long_name
            = "longitude" ; lon:units =
            "degrees_east" ; lon:axis =
            "X" ;

        byte ar_binary_tag(time, lat, lon) ;

            ar_binary_tag:description = "binary indicator of atmospheric river" ;
            ar_binary_tag:scheme = "Jiang" ;

            ar_binary_tag:version = "1.0" ;

    }
```

2.2 Methods with Regional Coverage

We acknowledge that not all algorithms will provide global data. In the case that only regional data is available, or in the case of some algorithms, data only at several grid points along the coast, we would request that an additional file is submitted with filename given by:

```
<Reanalysis dataset>.ar_mask.<Algorithm>.nc4
```

This NetCDF4 file should be based on the following template:

```
ncdump -h MERRA2.ar_mask.nc4

netcdf
MERRA2.ar_mask {
dimensions:
    lat =
    361 ;
    lon =
    576 ;

variables:
    double lat(lat) ;

        lat:standard_name =
        "latitude" ; lat:long_name =
        "latitude" ; lat:units =
        "degrees_north" ; lat:axis =
        "Y" ;
```

```
    double lon(lon) ;

        lon:standard_name =
        "longitude" ; lon:long_name
        = "longitude" ; lon:units =
        "degrees_east" ; lon:axis =
        "X" ;

    byte ar_binary_mask(lat, lon) ;

        ar_binary_mask:description = "atmospheric river regional coverage mask" ;
        ar_binary_mask:scheme = "Jiang" ;

        ar_binary_mask:version = "1.0" ;

}
```

The value of ar_binary_mask should be binary (either 1 or 0). Grid cells that are covered by the detection scheme should be given a value of 1, and those that are not covered should be given a value of 0.

Example masks from 1-month test participants are seen in Supplementary Figure S3.

3 Human Control Methodology

The same criteria for identification was used for both counting and tracking human controls and included the following:

1) IVT > 250 $kgm^{-1}s^{-1}$
2) IWV > 20mm
3) Length ~2 x width in IVT and/or IWV field;
4) Or at least a general stretched structure

5) Generally westerly flow
6) IVTy > 0 (poleward transport)

Data was compiled onto spreadsheets and available to ARTMIP participants.

3.1 Human control "Tracking"

The brightest IVT pixel is what is chosen as the recorded longitude and latitude. This single pixel is not followed temporally, so the given longitude and latitude might deviate from expectations (e.g., from the given longitude and latitude, it might look as if the AR is tracking south or west, but this is not the case). We expect any analysis performed on these locations to include some room for error. The locations we have pinpointed are good starting points, but of course do not capture the true scale of these events. Sometimes our best but still subjective judgement was used. These are highly dynamic systems, and they merge with or split from one another. We made notes where ARs track together, merge, or split off from another, but it is entirely possible we have missed some distinctions between events.

3.2 Human control "Counting" for (landfalling) events

An AR event is counted here if its IVT or IWV crosses a coastline. The vertical axis displays time step. Counting is binned along coasts at 1-degree resolution along the horizontal axis of each entered into a counting spreadsheet. Note that IVT and IWV were assessed separately since there is a spatiotemporal lag between IVT and IWV. The western coast of North America from a latitude of 32^{o}N to 55^{o}N, and the western and southwestern coast of Europe from 35^{o}N to 61^{o}N were considered. Each column of the last row of each counting spreadsheet sums all the values in each column. Each sum, therefore, represents the total number of instances where the IVT or IWV associated with an AR event crosses the coastline

at that 1-degree latitude range during the entire examined time period and is the data used for Figure 5.

Figure S1. February 2017 MERRA-2 time-average IVT 1-hour versus 3-hour differences. Units are $kgm^{-1}s^{-1}$.

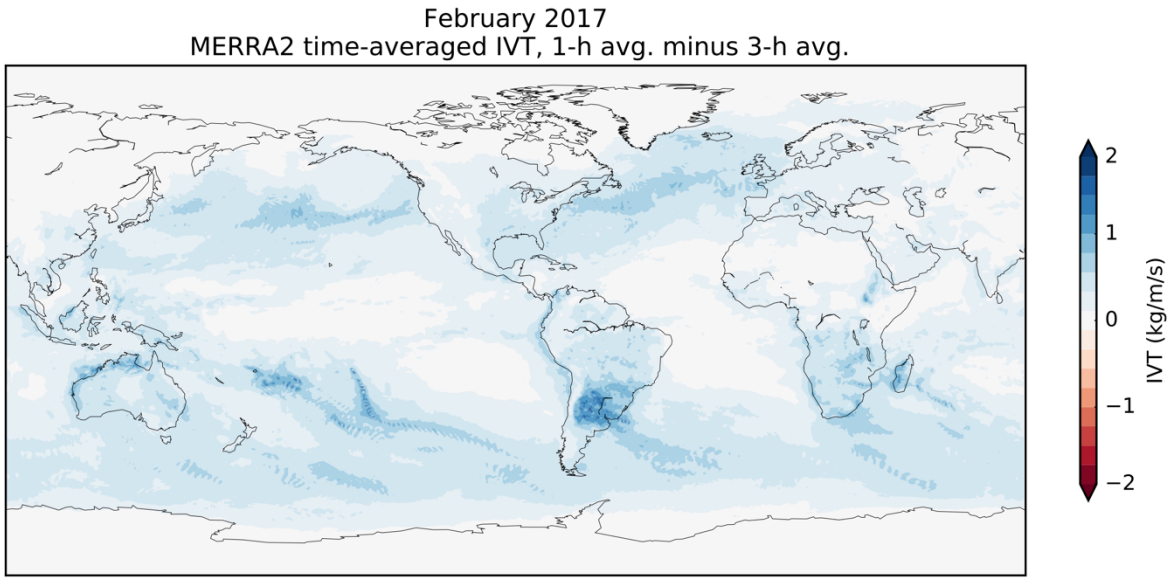

Figure S2. February 2017 MERRA-2 UCSD-computed 3-hourly IVT data versus 3-hour time-averaged data computed form averaging 1-hour MERRA-2 provided IVT differences (as in Figure S1). Units are $kgm^{-1}s^{-1}$.

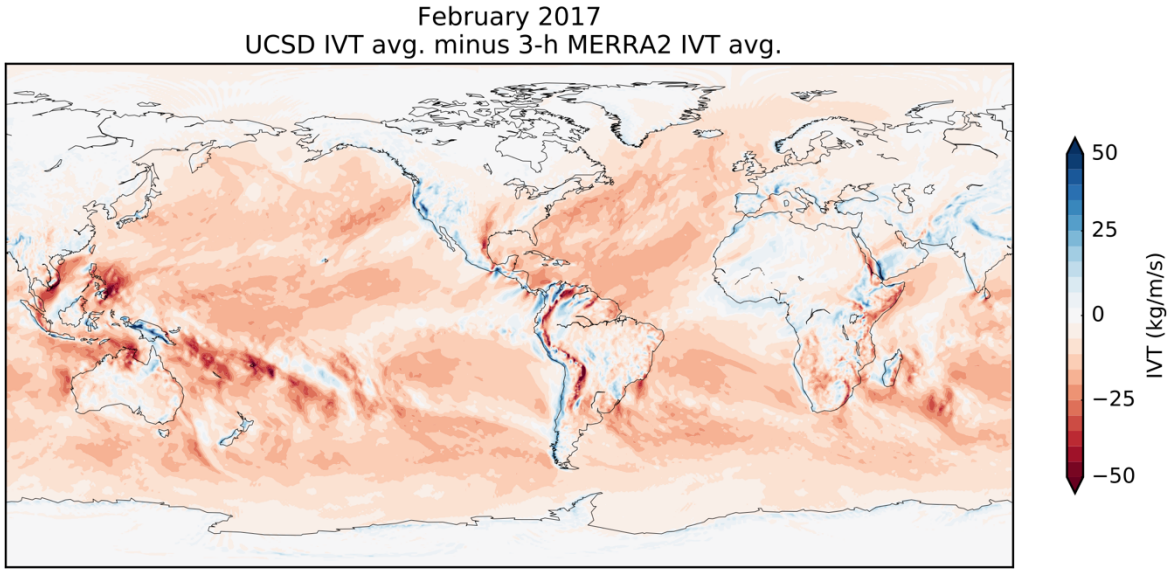

Figure S3. Regional masks provided by ARTMIP 1-month test participants.