A High resolution dataset of reference evaporation based on the WFDEI forcing

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Background

- The EU FP7 project eartH2Observe – construction of a global Water Resources Re-analysis dataset (model and EO data)
- Of value to large scale / global analysis and local applications in data sparse regions
- Based on the EU WATCH WFDEI forcing dataset ~ ERA-interim corrected with GPCP
- 3-hourly meteorological dataset for the period 1979 to 2012 at 0.5 degrees spatial resolution
- For local scale hydrological model application need for high resolution *reference evaporation*. (and precipitation and etc...)
- First set of downscaling actions using DEM information only

GLOBAL: Consistent but course  LOCAL: Detailed but sparse
Reference evaporation equations

- **Hargreaves** - temperature based
  \[ ET_o = 0.0023 \cdot R_a \cdot (\bar{T} + 17.8) \cdot TR^{0.50} \]

- **Priestley-Taylor** - temperature and radiation based
  \[ ET_o = \alpha \cdot \frac{\Delta R_n}{\lambda_v(\Delta + \gamma)} \]

- **Penman-Monteith** – physically based – (FAO Parameters)
  \[ \Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a} \]
  \[ ET_o = \frac{r_a}{\lambda_v \Delta + \gamma(1 + \frac{r_s}{r_a})} \]
DEM based Elevation Correction: $\Delta H$ (m)

\textit{difference between high and low resolution DEM for each high resolution grid-cell (m)}

- Temperature (lapse rate)
  \[ T_{\text{downscaled}} = T - L\Delta H \]

- Pressure (hydrostatic pressure assumption)
  \[ P_{\text{cor}} = P \left( \frac{T}{T + L\Delta H} \right) \frac{gM_0}{LR} \]

$g =$ gravitational constant (m s$^{-2}$), $R =$ specific gas constant for dry air (J mol$^{-1}$ K$^{-1}$), $M_0 =$ molecular weight of gas (g mol$^{-1}$), $L =$ lapse rate (k m$^{-1}$)
Radiation down-scaling and correction

Clear sky radiation
Each day of year
Computed from hourly timesteps
- Total on flat surface
- Direct on flat surface
- Total on DEM
- Direct on DEM
- nr of timesteps with shade

WFDEI total
Incoming radiation
- On flat surface

Linear interpolation to DEM resolution

Determine clear sky factor $K_c$

WFDEI Rad/Total Clear Sky (Flat surface)

Estimate WFDEI direct radiation

$K_c \times$ WFDEI total radiation
Rest is diffuse

Correct WFDEI Direct
Direct on DEM/Direct on flat
* WFDEI direct

Corrected WFDEI
Add WFDEI diffuse

11/30/15

Deltarces
Radiation down-scaling and correction
Radiation down-scaling and correction
Radiation down-scaling and correction
Case-study Murumbidgee (Australia)

- Topography: 2,000 m east – 50 m west
- Area: 84,000 km²
- Rainfall: 1,700 mm/y east – 350 mm/y west
- Evaporation: 1,000 mm/y south-east – 1,800 mm/y west
- Average annual flow at Wagga Wagga ≈ 123 m³/s
- Direct Runoff dominated

Reference: Local high resolution gauging station based gridded datasets (0.05°), sourced from the Australian Bureau of Meteorology (Jones et al., 2009).

Comparison for the years 1979 - 2010
Long-term average reference evaporation

Top: local reference
Middle: non down-scaled
Bottom: down-scaled
Daily time-series for the Murumbidgee

Non down-scaled

Down-scaled
Correlation between daily reference evaporation time-series derived from the global dataset and reference Hargreaves evaporation derived from the local Australian dataset for Canberra airport.

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Penman-Monteith</th>
<th>Priestley-Taylor</th>
<th>Hargreaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 degrees</td>
<td>0.9325</td>
<td>0.9259</td>
<td>0.9592</td>
</tr>
<tr>
<td>1 km</td>
<td>0.9324</td>
<td>0.9258</td>
<td>0.9592</td>
</tr>
</tbody>
</table>
Five year average daily evaporation at the original 0.5 degrees resolution

Five year average daily evaporation with radiation correction and down-scaling to 10 km
Top-left: HG reference potential evaporation derived from the WorldClim dataset (mm/day). Remaining maps: bias from the WorldClim estimate (mm/day) for HG (bottom-left), PM (top-right) and PT (bottom-right).
Climatology for a number of selected Köppen climate zones. Blue: PM, Green: PT and Red: HG

Differences large in the more extreme climate zones. (simplification)
Conclusion

The presented reference potential evaporation estimates resemble the WorldClim dataset quite well.

Largest differences are found over the Saharas, Amazon and desert region of Australia. This suggests that the global results should be used with caution in the more extreme climate zones.

Results per climate zones suggest that the differences between the WordClim dataset and the present results originate from the three different equations.

The global and downscaled global reference evaporation estimates show high similarity with the local Hargreaves evaporation in local testing.
Outlook

A global reference evaporation dataset for the period 1979-2012 at a resolution of 10 km (1km may happen later) is available at the eartH2Observe data portal: https://wci.earth2observe.eu

Further evaluation of the dataset will at least be carried out in case-studies in Colombia, Bangladesh and the Mediterranean region

Next in line: precipitation (easy ;-))
DIY: Get the tools from GitHub
Introduction

e2o_downscaling-tools consists of a number of python programs and procedures that facilitate local application of the earth2observe global water resources reanalysis. The tools can connect directly to the project’s data server and save (resampled) data to a local computer for further analysis or direct application. The current first versions of the tool focuses on downscaling the global forcing dataset used in the project :cite:`weedonwfdei2014`.

Quick start using the examples

The steps below should allow you to run the examples on a windows machine.

1. Open up a command line
2. Navigate to the directory containing the tools
3. Run `e2o-getvar` with the option `--example` followed by the example file name.

Example usage:

```
$ e2o-getvar --example example01
```

This will output the necessary command to run the example.

This documentation is for version 0.1 of e2o_dstools, release 2015 This documentation was generated October 09, 2015.
DIY: Start...

```
e2o_getvar.py -I infile [-l loglevel][-h]
  -I infile - ini file with settings which data
  -l loglevel (must be one of DEBUG, WARNING, ERROR)
jaap@jaap-XPS13-9333:-/repos/downscaling-tools/examples/dstools/e2o_getvar.py -I examplerun1.ini
2015-11-29 23:30:18,840 - e2o_getvar - DEBUG - File jaap@jaap-XPS13-9333:-/repos/downscaling-tools/examples/dstools/e2o_getvar.py -I examplerun1.ini
2015-11-29 23:30:18,840 - e2o_getvar - DEBUG - Read run1.ini
2015-11-29 23:30:18,841 - e2o_getvar - INFO - returning default downscaling
2015-11-29 23:30:18,841 - e2o_getvar - INFO - returning default downscaling: lowResDEM
2015-11-29 23:30:18,841 - e2o_getvar - DEBUG - Done reading settings
  WARNING: Unable to read min val in CSF.
  WARNING: Unable to read max val in CSF.
True
  root group (NETCDF3_CLASSIC data model, file format UNDEFINED)
  id: Tair_E2085_197901
  naming authority: ecmwf.int
  Metadata Conventions: Unidata Dataset Discovery v1.0
```

```
serverroot = http://wci.earth2observe.eu/thredds/dodsC/
wrsetroot = ecmwf/met_forcing_v0/

[selection]
latmax = 55.25
latmin = 44.25
lonmax = 14.75
lonmin = 4.25
startyear = 1979
deyear = 2012
startmonth = 1
endmonth = 12
startday = 1
day = 31
```

```
# Add any of the following variables here
Temperature=True
DownwellingLongWaveRadiation=True
SurfaceAtmosphericPressure=True
NearSurfaceSpecificHumidity=True
SurfaceIncidentShortwaveRadiation=True
SnowfallRate=True
NearSurfaceWindSpeed=True
Rainfall = True
        0.1
```