



I N T E G R A T E D S I N K E N H A N C E M E N T A S S E S S M E N T



I N S E A
P A R T N E R S

Preparation and Generation of Climatic Input Data Sets for the Biophysical Process Modelling – EPIC

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Biophysical Process Modelling - **EPIC**

- Climatic Input -

Why?

Agricultural modelling requires the availability of daily data

- minimum and maximum daily temperatures
- amount of precipitation
- radiation

MARS data provides European coverage for the years 1992-2002 as daily elements

However a longer time period would be preferred.

Biophysical Process Modelling - **EPIC**

- Climatic Input -

What? How?

Data supplied by the University of East Anglia (EA) presents

global coverage of monthly averages for the period 1901-2002

18 scenarios for the period 2001-2100.

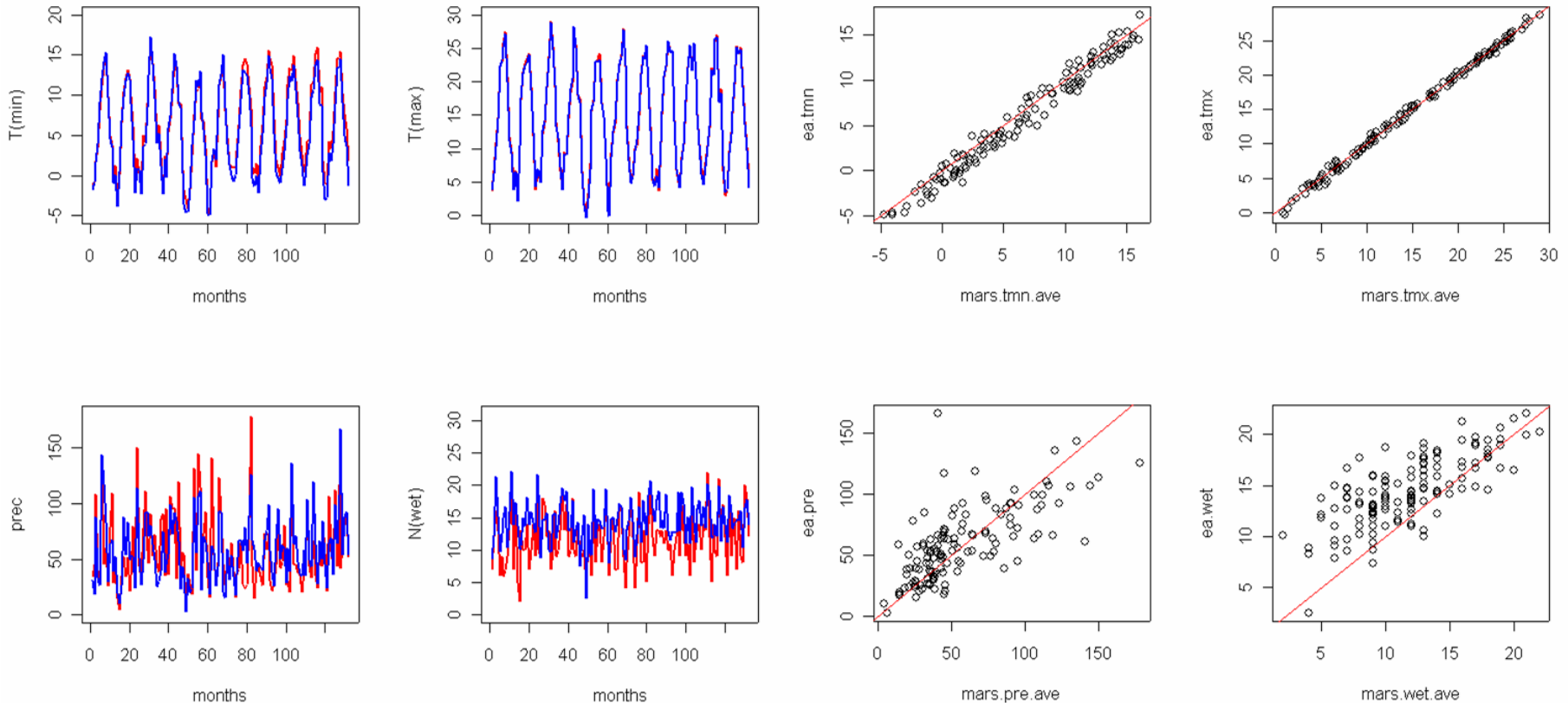
Analysis of time series and correlation between MARS and EA data set of European coverage

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- Climatic Input -

How?

Monthly means - evaluated from the MARS data
- compared with the corresponding data from the EA



Time – series jan 1992 – dec 2002 for
MARS (red) and EA (blue) data

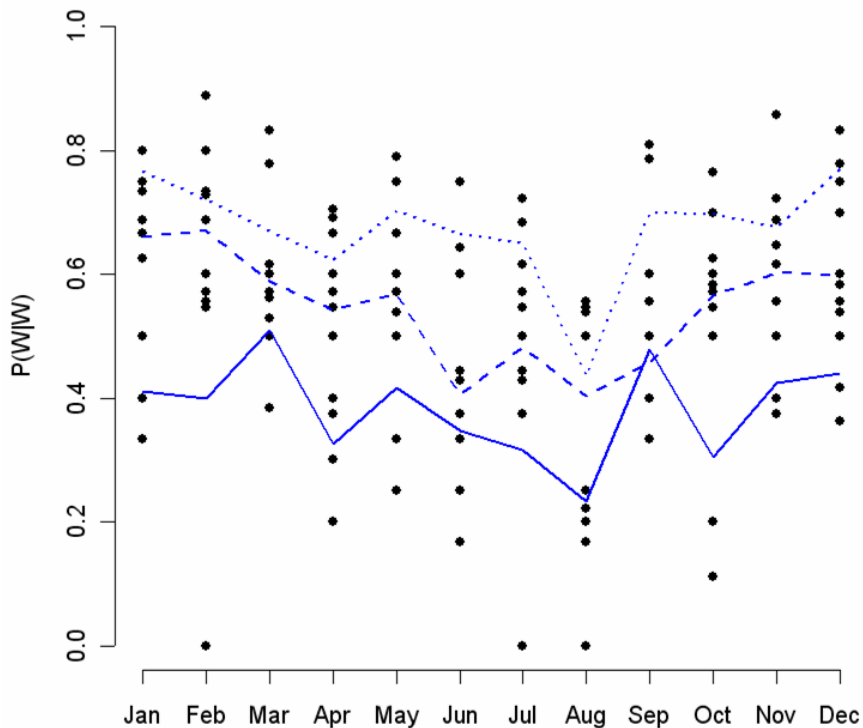
Correlation for the estimated monthly mean Tmin, Tmax, precipitation and N(wet) between MARS (x-axis) and EA(y-axis) data. Coefficients lay between 0,7 and 0,9.

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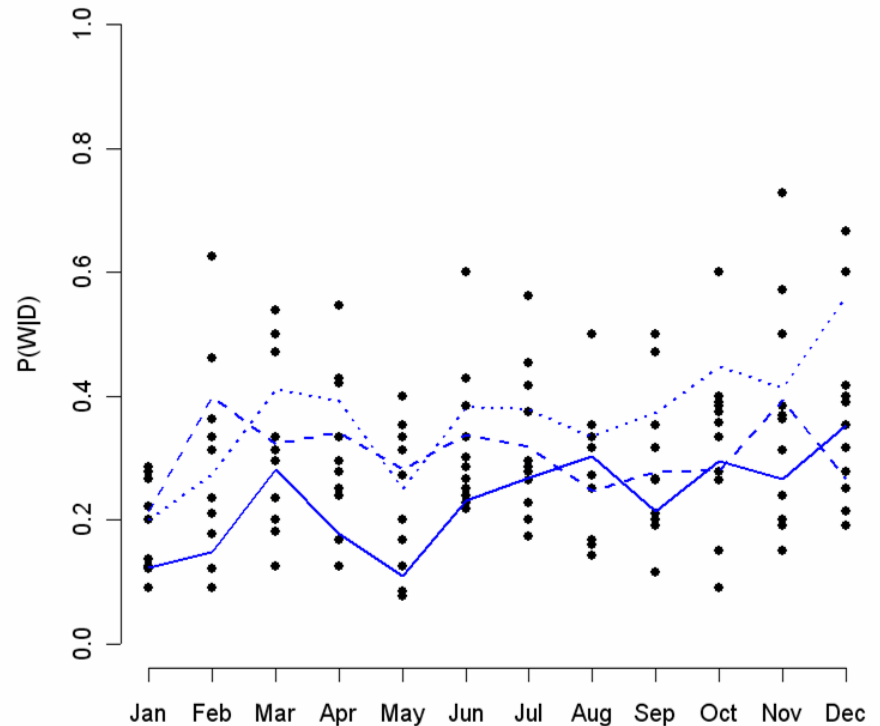
How?

- Climatic Input -

Markov Chain for wet, mid, dry months probabilities to describe the general monthly wetness



Transition probability of a wet day after wet day for a dry (solid line), medium (no-solid line) and wet (dotted line) month.



Transition probabilities of a wet day after a dry day for a dry (solid line), medium (non-solid line) and wet (dotted line) month.

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partial results

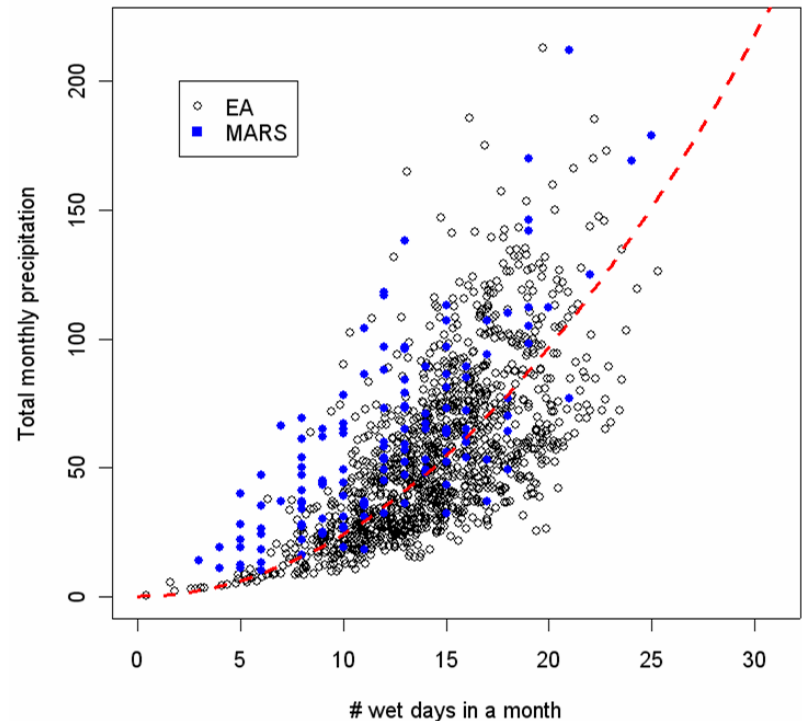
- Climatic Input -

- ✓ missing radiation is estimated with the data of the cloudiness

radiation [MJ/m^2] = \mathbf{f} {day length, latitude, atmospheric transmissivity, solar declination, solar elevation} RIVINGTON et al. (2002)

- ✓ missing wet day data for scenarios are derived from a quadratic relationship between precipitation and wet days from both data sets (MARS and EA)

→ α factor for each cell



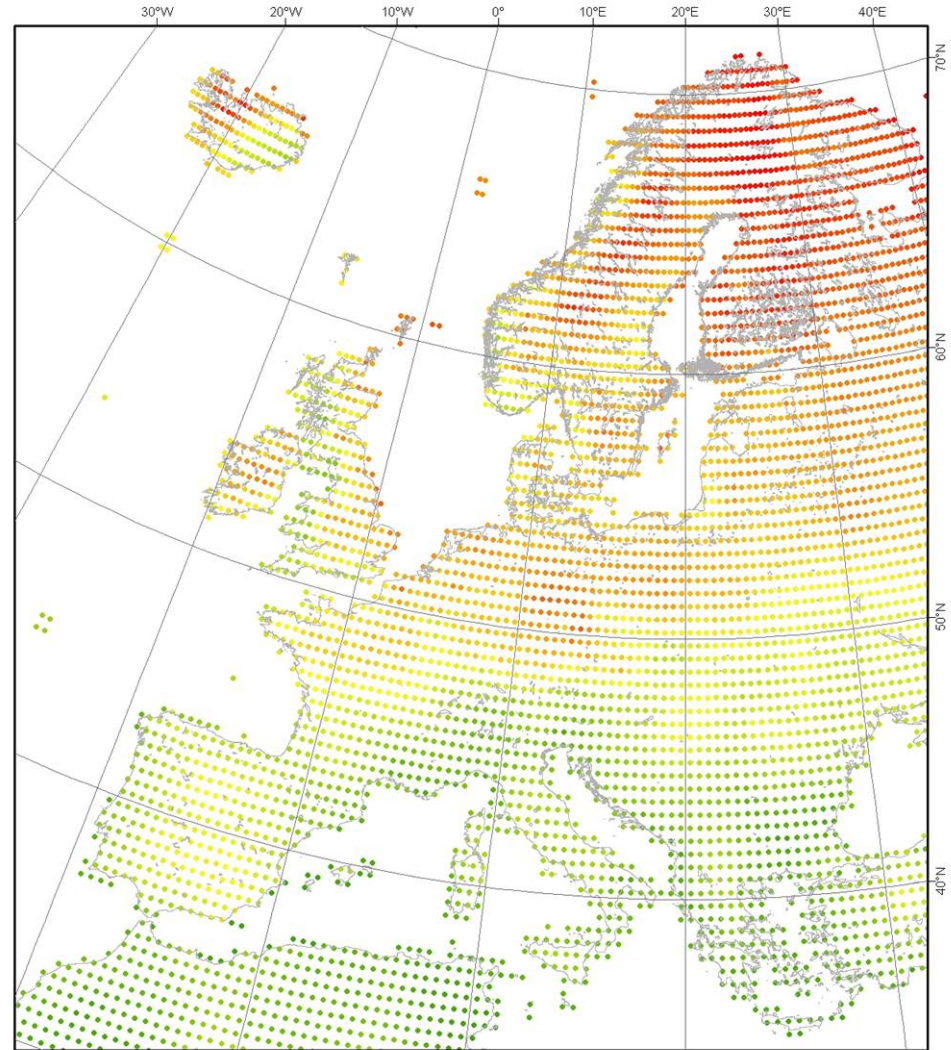
Biophysical Process Modelling - EPIC

partial results

- Climatic Input -

✓ alpha values for
Europa, range:
22 - 109

$$\alpha = \frac{\sum \sqrt{\text{precipitation}_{EA} * \text{wet days}_{EA}}}{\sum \text{precipitation}_{EA}}$$



Biophysical Process Modelling - EPIC

technical solution –
data generation

- Climatic Input -

A programme was written to generate the various scenarios and compute the missing climatic elements

scenario	units per degree of global warming
A1FI PCM	3,045
A1FI CGCM2	4,382
A1FI CSIRO2	4,855
A1FI HadCM3	4,863
A2 PCM	2,462
A2 CGCM2	3,548
A2 CSIRO2	3,938
A2 HadCM3	3,931
A2 ECHam4	1,000
B2 PCM	1,894
B2 CGCM2	2,462
B2 CSIRO2	3,139
B2 HadCM3	3,070
B2 ECHam4	1,000
B1 PCM	1,541
B1 CGCM2	2,023
B1 CSIRO2	2,592
B1 HadCM3	2,521

climate variable	units	minimum	maximum	multiply
temperature	°C	none	none	0,1
diurnal temperature range	°C	0,1	none	0,1
minimum temperature	°C	none	none	0,1
maximum temperature	°C	none	none	0,1
precipitation	mm	0,0	none	0,1
wet days		0,0	30,0	0,01
vapour pressure	hPa	0,0	none	0,1
cloud cover	%	0,0	100,0	0,1
radiation	MJ/m²	0,0	none	1,0

climate variable	hh:mm:ss
temperature	00:01:30
diurnal temperature range	00:01:30
minimum-maximum temperature	00:06:00
precipitation	00:01:30
wet days	00:01:40
vapour pressure	00:01:30
cloud cover	00:01:30
radiation	01:50:00

The estimation of consumption in computation is done for the whole data set.

requested by EPIC are aggregated data in different time steps:

mean values for each climatic variable per month in 10, 25, 50 and 100 years.

Biophysical Process Modelling - EPIC

technical solution –
data generation

- Climatic Input -

result files are stored as tables in a database

postgresql database engine is used

SQL-Statements for creating and storing

```
create table scenario_pcm_a1fi_mean10_cld (  
  interval int4,  
  lon float4,  
  lat float4,  
  jan float4,  
  feb float4,  
  mar float4,  
  apr float4,  
  may float4,  
  jun float4,  
  jul float4,  
  aug float4,  
  sep float4,  
  oct float4,  
  nov float4,  
  dec float4  
);
```

```
copy cru_ts_2_10_1901_2002_mean100_cld from 'cru_ts_2_10_1901_2002_mean100_cld.txt' delimiter ';';
```

Biophysical Process Modelling - EPIC

technical solution –
data generation

- Climatic Input -

The screenshot displays the PostgreSQL GUI. On the left, a tree view shows the database structure with tables like 'operatorn', 'sequenzen', and various 'tbl' tables. The main window shows the 'Eigenschaften' (Properties) for a table, including fields like 'Name', 'OID', 'Eigentümer', and 'ACL'. Below this, the 'CREATE TABLE' statement for 'tbl' is visible, listing columns such as 'interval', 'lat', 'lon', 'fcb', 'n', 'm', 'p', 'q', 'r', 's', 't', 'u', 'v', 'w', 'x', 'y', 'z', 'aa', 'ab', 'ac', 'ad', 'ae', 'af', 'ag', 'ah', 'ai', 'aj', 'ak', 'al', 'am', 'an', 'ao', 'ap', 'aq', 'ar', 'as', 'at', 'au', 'av', 'aw', 'ax', 'ay', 'az', 'ba', 'bb', 'bc', 'bd', 'be', 'bf', 'bg', 'bh', 'bi', 'bj', 'bk', 'bl', 'bm', 'bn', 'bo', 'bp', 'bq', 'br', 'bs', 'bt', 'bu', 'bv', 'bw', 'bx', 'by', 'bz', 'ca', 'cb', 'cc', 'cd', 'ce', 'cf', 'cg', 'ch', 'ci', 'cj', 'ck', 'cl', 'cm', 'cn', 'co', 'cp', 'cq', 'cr', 'cs', 'ct', 'cu', 'cv', 'cw', 'cx', 'cy', 'cz', 'da', 'db', 'dc', 'dd', 'de', 'df', 'dg', 'dh', 'di', 'dj', 'dk', 'dl', 'dm', 'dn', 'do', 'dp', 'dq', 'dr', 'ds', 'dt', 'du', 'dv', 'dw', 'dx', 'dy', 'dz', 'ea', 'eb', 'ec', 'ed', 'ee', 'ef', 'eg', 'eh', 'ei', 'ej', 'ek', 'el', 'em', 'en', 'eo', 'ep', 'eq', 'er', 'es', 'et', 'eu', 'ev', 'ew', 'ex', 'ey', 'ez', 'fa', 'fb', 'fc', 'fd', 'fe', 'ff', 'fg', 'fh', 'fi', 'fj', 'fk', 'fl', 'fm', 'fn', 'fo', 'fp', 'fq', 'fr', 'fs', 'ft', 'fu', 'fv', 'fw', 'fx', 'fy', 'fz', 'ga', 'gb', 'gc', 'gd', 'ge', 'gf', 'gg', 'gh', 'gi', 'gj', 'gk', 'gl', 'gm', 'gn', 'go', 'gp', 'gq', 'gr', 'gs', 'gt', 'gu', 'gv', 'gw', 'gx', 'gy', 'gz', 'ha', 'hb', 'hc', 'hd', 'he', 'hf', 'hg', 'hh', 'hi', 'hj', 'hk', 'hl', 'hm', 'hn', 'ho', 'hp', 'hq', 'hr', 'hs', 'ht', 'hu', 'hv', 'hw', 'hx', 'hy', 'hz', 'ia', 'ib', 'ic', 'id', 'ie', 'if', 'ig', 'ih', 'ii', 'ij', 'ik', 'il', 'im', 'in', 'io', 'ip', 'iq', 'ir', 'is', 'it', 'iu', 'iv', 'iw', 'ix', 'iy', 'iz', 'ja', 'jb', 'jc', 'jd', 'je', 'jf', 'jg', 'jh', 'ji', 'jj', 'jk', 'jl', 'jm', 'jn', 'jo', 'jp', 'jq', 'jr', 'js', 'jt', 'ju', 'jv', 'jw', 'jx', 'jy', 'jz', 'ka', 'kb', 'kc', 'kd', 'ke', 'kf', 'kg', 'kh', 'ki', 'kj', 'kl', 'km', 'kn', 'ko', 'kp', 'kq', 'kr', 'ks', 'kt', 'ku', 'kv', 'kw', 'kx', 'ky', 'kz', 'la', 'lb', 'lc', 'ld', 'le', 'lf', 'lg', 'lh', 'li', 'lj', 'lk', 'll', 'lm', 'ln', 'lo', 'lp', 'lq', 'lr', 'ls', 'lt', 'lu', 'lv', 'lw', 'lx', 'ly', 'lz', 'ma', 'mb', 'mc', 'md', 'me', 'mf', 'mg', 'mh', 'mi', 'mj', 'mk', 'ml', 'mm', 'mn', 'mo', 'mp', 'mq', 'mr', 'ms', 'mt', 'mu', 'mv', 'mw', 'mx', 'my', 'mz', 'na', 'nb', 'nc', 'nd', 'ne', 'nf', 'ng', 'nh', 'ni', 'nj', 'nk', 'nl', 'nm', 'nn', 'no', 'np', 'nq', 'nr', 'ns', 'nt', 'nu', 'nv', 'nw', 'nx', 'ny', 'nz', 'oa', 'ob', 'oc', 'od', 'oe', 'of', 'og', 'oh', 'oi', 'oj', 'ok', 'ol', 'om', 'on', 'oo', 'op', 'oq', 'or', 'os', 'ot', 'ou', 'ov', 'ow', 'ox', 'oy', 'oz', 'pa', 'pb', 'pc', 'pd', 'pe', 'pf', 'pg', 'ph', 'pi', 'pj', 'pk', 'pl', 'pm', 'pn', 'po', 'pp', 'pq', 'pr', 'ps', 'pt', 'pu', 'pv', 'pw', 'px', 'py', 'pz', 'qa', 'qb', 'qc', 'qd', 'qe', 'qf', 'qg', 'qh', 'qi', 'qj', 'qk', 'ql', 'qm', 'qn', 'qo', 'qp', 'qq', 'qr', 'qs', 'qt', 'qu', 'qv', 'qw', 'qx', 'qy', 'qz', 'ra', 'rb', 'rc', 'rd', 're', 'rf', 'rg', 'rh', 'ri', 'rj', 'rk', 'rl', 'rm', 'rn', 'ro', 'rp', 'rq', 'rr', 'rs', 'rt', 'ru', 'rv', 'rw', 'rx', 'ry', 'rz', 'sa', 'sb', 'sc', 'sd', 'se', 'sf', 'sg', 'sh', 'si', 'sj', 'sk', 'sl', 'sm', 'sn', 'so', 'sp', 'sq', 'sr', 'ss', 'st', 'su', 'sv', 'sw', 'sx', 'sy', 'sz', 'ta', 'tb', 'tc', 'td', 'te', 'tf', 'tg', 'th', 'ti', 'tj', 'tk', 'tl', 'tm', 'tn', 'to', 'tp', 'tq', 'tr', 'ts', 'tt', 'tu', 'tv', 'tw', 'tx', 'ty', 'tz', 'ua', 'ub', 'uc', 'ud', 'ue', 'uf', 'ug', 'uh', 'ui', 'uj', 'uk', 'ul', 'um', 'un', 'uo', 'up', 'uq', 'ur', 'us', 'ut', 'uu', 'uv', 'uw', 'ux', 'uy', 'uz', 'va', 'vb', 'vc', 'vd', 've', 'vf', 'vg', 'vh', 'vi', 'vj', 'vk', 'vl', 'vm', 'vn', 'vo', 'vp', 'vq', 'vr', 'vs', 'vt', 'vu', 'vv', 'vw', 'vx', 'vy', 'vz', 'wa', 'wb', 'wc', 'wd', 'we', 'wf', 'wg', 'wh', 'wi', 'wj', 'wk', 'wl', 'wm', 'wn', 'wo', 'wp', 'wq', 'wr', 'ws', 'wt', 'wu', 'wv', 'ww', 'wx', 'wy', 'wz', 'xa', 'xb', 'xc', 'xd', 'xe', 'xf', 'xg', 'xh', 'xi', 'xj', 'xk', 'xl', 'xm', 'xn', 'xo', 'xp', 'xq', 'xr', 'xs', 'xt', 'xu', 'xv', 'xw', 'xx', 'xy', 'xz', 'ya', 'yb', 'yc', 'yd', 'ye', 'yf', 'yg', 'yh', 'yi', 'yj', 'yk', 'yl', 'ym', 'yn', 'yo', 'yp', 'yq', 'yr', 'ys', 'yt', 'yu', 'yv', 'yw', 'yx', 'yy', 'yz', 'za', 'zb', 'zc', 'zd', 'ze', 'zf', 'zg', 'zh', 'zi', 'zj', 'zk', 'zl', 'zm', 'zn', 'zo', 'zp', 'zq', 'zr', 'zs', 'zt', 'zu', 'zv', 'zw', 'zx', 'zy', 'zz'.

The bottom window shows a query result table with columns: number, lat, lon, description, interval, fcb, n, m, p, q, r, s, t, u, v, w, x, y, z, aa, ab, ac, ad, ae, af, ag, ah, ai, aj, ak, al, am, an, ao, ap, aq, ar, as, at, au, av, aw, ax, ay, az, ba, bb, bc, bd, be, bf, bg, bh, bi, bj, bk, bl, bm, bn, bo, bp, bq, br, bs, bt, bu, bv, bw, bx, by, bz, ca, cb, cc, cd, ce, cf, cg, ch, ci, cj, ck, cl, cm, cn, co, cp, cq, cr, cs, ct, cu, cv, cw, cx, cy, cz, da, db, dc, dd, de, df, dg, dh, di, dj, dk, dl, dm, dn, do, dp, dq, dr, ds, dt, du, dv, dw, dx, dy, dz, ea, eb, ec, ed, ee, ef, eg, eh, ei, ej, ek, el, em, en, eo, ep, eq, er, es, et, eu, ev, ew, ex, ey, ez, fa, fb, fc, fd, fe, ff, fg, fh, fi, fj, fk, fl, fm, fn, fo, fp, fq, fr, fs, ft, fu, fv, fw, fx, fy, fz, ga, gb, gc, gd, ge, gf, gg, gh, gi, gj, gk, gl, gm, gn, go, gp, gq, gr, gs, gt, gu, gv, gw, gx, gy, gz, ha, hb, hc, hd, he, hf, hg, hh, hi, hj, hk, hl, hm, hn, ho, hp, hq, hr, hs, ht, hu, hv, hw, hx, hy, hz, ia, ib, ic, id, ie, if, ig, ih, ii, ij, ik, il, im, in, io, ip, iq, ir, is, it, iu, iv, iw, ix, iy, iz, ja, jb, jc, jd, je, jf, jg, jh, ji, jj, jk, jl, jm, jn, jo, jp, jq, jr, js, jt, ju, jv, jw, jx, jy, jz, ka, kb, kc, kd, ke, kf, kg, kh, ki, kj, kl, km, kn, ko, kp, kq, kr, ks, kt, ku, kv, kw, kx, ky, kz, la, lb, lc, ld, le, lf, lg, lh, li, lj, lk, ll, lm, ln, lo, lp, lq, lr, ls, lt, lu, lv, lw, lx, ly, lz, ma, mb, mc, md, me, mf, mg, mh, mi, mj, mk, ml, mm, mn, mo, mp, mq, mr, ms, mt, mu, mv, mw, mx, my, mz, na, nb, nc, nd, ne, nf, ng, nh, ni, nj, nk, nl, nm, nn, no, np, nq, nr, ns, nt, nu, nv, nw, nx, ny, nz, oa, ob, oc, od, oe, of, og, oh, oi, oj, ok, ol, om, on, oo, op, oq, or, os, ot, ou, ov, ow, ox, oy, oz, pa, pb, pc, pd, pe, pf, pg, ph, pi, pj, pk, pl, pm, pn, po, pp, pq, pr, ps, pt, pu, pv, pw, px, py, pz, qa, qb, qc, qd, qe, qf, qg, qh, qi, qj, qk, ql, qm, qn, qo, qp, qq, qr, qs, qt, qu, qv, qw, qx, qy, qz, ra, rb, rc, rd, re, rf, rg, rh, ri, rj, rk, rl, rm, rn, ro, rp, rq, rr, rs, rt, ru, rv, rw, rx, ry, rz, sa, sb, sc, sd, se, sf, sg, sh, si, sj, sk, sl, sm, sn, so, sp, sq, sr, ss, st, su, sv, sw, sx, sy, sz, ta, tb, tc, td, te, tf, tg, th, ti, tj, tk, tl, tm, tn, to, tp, tq, tr, ts, tt, tu, tv, tw, tx, ty, tz, ua, ub, uc, ud, ue, uf, ug, uh, ui, uj, uk, ul, um, un, uo, up, uq, ur, us, ut, uu, uv, uw, ux, uy, uz, va, vb, vc, vd, ve, vf, vg, vh, vi, vj, vk, vl, vm, vn, vo, vp, vq, vr, vs, vt, vu, vv, vw, vx, vy, vz, wa, wb, wc, wd, we, wf, wg, wh, wi, wj, wk, wl, wm, wn, wo, wp, wq, wr, ws, wt, wu, wv, ww, wx, wy, wz, xa, xb, xc, xd, xe, xf, xg, xh, xi, xj, xk, xl, xm, xn, xo, xp, xq, xr, xs, xt, xu, xv, xw, xx, xy, xz, ya, yb, yc, yd, ye, yf, yg, yh, yi, yj, yk, yl, ym, yn, yo, yp, yq, yr, ys, yt, yu, yv, yw, yx, yy, yz, za, zb, zc, zd, ze, zf, zg, zh, zi, zj, zk, zl, zm, zn, zo, zp, zq, zr, zs, zt, zu, zv, zw, zx, zy, zz.

PostgreSQL is a free object-relational database server (database management system) Short overview is given on:

<http://en.wikipedia.org/wiki/PostgreSQL>

query whatever you need with

➤ stored data

➤ embedded SQL

or

INSISE

Biophysical Process Modelling - EPIC

supplemental
elements

- Climatic Input -

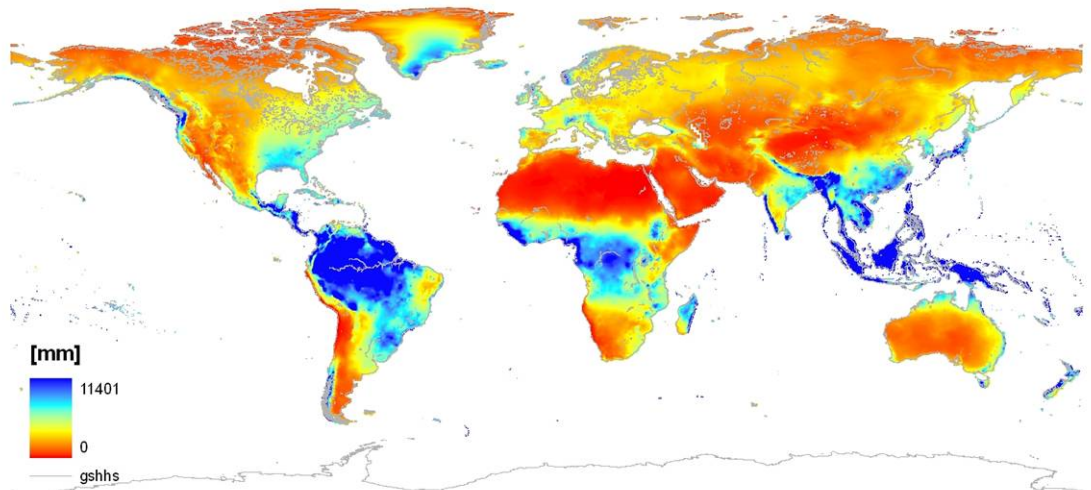
High quality climatic data sets are available as grids:

Monthly data

- ✓ Tmin, Tmax [°C]
- ✓ Precipitation [mm]
- ✓

for the period 1950-2000 as interpolated surfaces (HIJMANS et. al 2005) and 19 additional bioclimatic variables:

- ✓ Annual Mean Temperature
- ✓ Mean Diurnal Range
- ✓ Isothermality
- ✓ Temperature Seasonality
- ✓ Max Temperature of Warmest Month
- ✓ Min Temperature of Coldest Month
- ✓ Temperature Annual Range
- ✓ Mean Temperature of Wettest Quarter
- ✓ Mean Temperature of Driest Quarter
- ✓ Mean Temperature of Warmest Quarter
- ✓ Mean Temperature of Coldest Quarter
- ✓ Annual Precipitation
- ✓ Precipitation of Wettest Month
- ✓ Precipitation of Driest Month
- ✓ Precipitation Seasonality
- ✓ Precipitation of Wettest Quarter
- ✓ Precipitation of Driest Quarter
- ✓ Precipitation of Warmest Quarter
- ✓ Precipitation of Coldest Quarter



annual precipitation as 1k resolution grid (HIJMANS et. al 2005)

Biophysical Process Modelling - EPIC

supplemental
elements

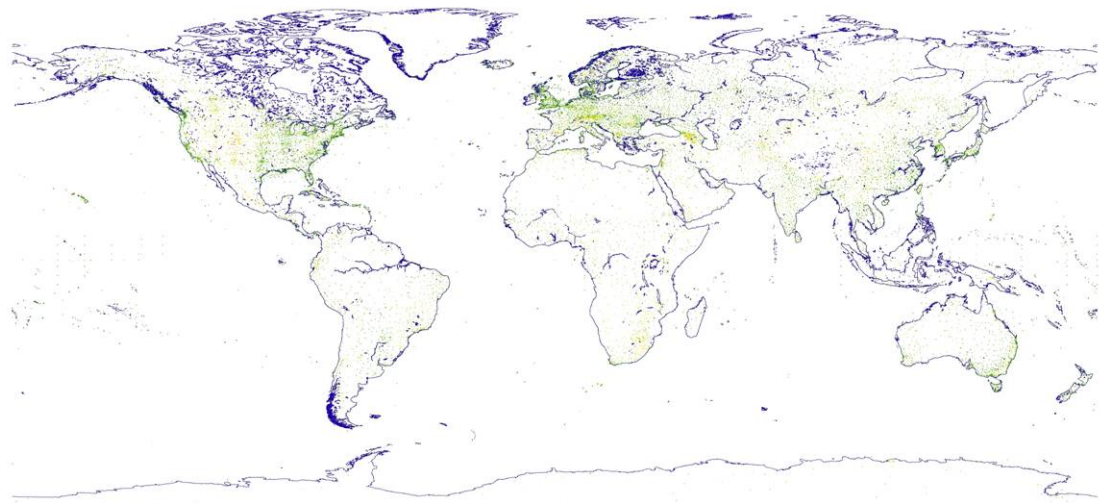
- Climatic Input -

High quality climatic data set are available as database:

NCDC Data (OVER 8000 WORLDWIDE STATIONS) 1994 - 2005

Daily elements as available from each station are:

- ✓ Mean temperature
- ✓ Mean dew point
- ✓ Mean sea level pressure
- ✓ Mean station pressure
- ✓ Precipitation amount
- ✓ Snow depth
- ✓ Indicator for occurrence of: Fog, Rain or Drizzle, Snow or Ice Pellets, Hail, Thunder, Tornado/Funnel Cloud
- ✓ Mean visibility
- ✓ Mean wind speed
- ✓ Maximum sustained wind speed
- ✓ Maximum wind gust
- ✓ Maximum temperature
- ✓ Minimum temperature



Source: NCDC
Integrated Surface Hourly Database Station History, January 2005

Storage of daily weather elements take from > 8,000 world-wide weather stations in a **postgreSQL** database

As result **144 tables** with daily weather in monthly ranges are being generated covering the time period of January 1994 to December 2005. They comprise approximately **32 million records**.

Biophysical Process Modelling - **EPIC**

- Climatic Input -

results

- ✓ all necessary climatic input elements are worldwide available.
- ✓ various scenarios allow steering of modelling process
- ✓ recognizable trends accounted for in simulation