MACSUR Cross-Theme workshop
Regional Pilot Studies
Braunschweig, June 5-6, 2013

CropM:
1) What climate change and socio-economic data/infos are particularly important?
2) [What information is required from TradeM & LiveM ?]

Reimund Rötter and Frank Ewert,
CropM coordinators
# CropM Work Packages

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<td>WP1</td>
<td>Model intercomparison (develop protocols; extend sites, crops)</td>
<td>Christian Kersebaum (GER) Marco Bindi (IT)</td>
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<td>WP2</td>
<td>Model improvements through generating and compiling data</td>
<td>Jorgen Olesen (DK) Mirek Trnka (CZ)</td>
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<td>WP3</td>
<td>Scaling methods and model linking</td>
<td>Frank Ewert (GER), Sander Janssen (NL)</td>
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<td>Martin van Ittersum (NL)</td>
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<td>WP4</td>
<td>Scenario development and impact uncertainty analysis</td>
<td>Reimund Rötter (FI), Daniel Wallach (FR), M Semenov (UK), Mike Rivington (UK)</td>
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<td>WP5</td>
<td>Capacity building</td>
<td>John R Porter (DK)</td>
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<td>WP6</td>
<td>Case studies on impact assessment (cross cutting theme package and linkage to decision-making)</td>
<td>Jan Verhagen (NL) Derek Stewart (UK) [Pier Paolo Roggero (IT)]</td>
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Ongoing activities \textit{(a selection)}

- WP 1: Model intercomparison using long-term crop rotation experiments across Europe (Kersebaum/Kollas et al)

- WP 2: Data sharing facility and studies on crop-weather relationships and extremes (Trnka/Olesen et al.)

- WP 3: Comparison of point- and grid-based upscaling for wheat in NRW (van Bussel/Ewert et al.)

- WP 4: Improved method for probabilistic assessment of climate change impacts on food and forage production /N-C-S application (Pirttioja/Rötter et al.)
CropM - Demands for crop modelling:

- Better understanding of crop growth and yield
  - Under climate change
  - Improving food security (supply side)
- Impacts assessments:
  - Identification of risks
  - Identification of adaptation and mitigation options
  - Integrated bio-physical and socio-economic
  - Multi-scale (from field, to farm, region and continent)
Challenge for MACSUR: Combine impact and capacity approaches to adaptation planning *(after Vermeulen et al., 2013, PNAS)*
Uncertainty chain in CC impact assessment

Forcing scenario(s)
SRES - RCP

Observed climate data

(GCM)
Climate change projections

(Down-)Scaling/Regionalisation
(delta change, RCM bias correction, weather generator)
Climate scenario data

(Plant-soil) Impact models
Impact projections
at different spatiotemporal scales

Impact on Food Production (and Land Use)

(Rötter et al. 2013, Acta Agric Scand.)
Climate is changing...

Importance of climatic variability and extremes

Figure 1 | Estimated CO₂ emissions over the past three decades compared with the IS92, SRES and the RCPs. The SRES data are not shown, but the most relevant (SA90-A) is similar to IS92-A and IS92-F. The uncertainty in historical emissions is ±5% (one standard deviation). Scenario data is generally reported at decadal intervals and we use linear interpolation for intermediate years.
(Source: Peters, 2013; Nat Clim Change)

Shift in PDF of July temperatures S Finland (Source: Räisänen 2010)

Source: Coumou & Rahmsdorf, 2012
What kind of extremes and impacts are we talking about?

(1) Heat shocks (high Tmax) => floret mortality, heat waves => leaf senescence, shortened grain-filling period

(2) Dry spells/water deficits => stomatal closure, photosynthesis reduced, leaf senescence.......

(3) Heavy rain => water logging, oxygen stress; post-maturity delayed harvest; wetness increasing occurrence of pests/diseases

(4) Heavy rain/warm winters – indirect via soil processes (e.g. nitrogen losses by leaching)

Changes in the rate of (a) C3 photosynthesis and respiration and (b) rate of crop development as a function of temperature.

Relationship between percentage fruit set (angular transformed data) and mean floral temperature, from 08:00 to 14:00 h, 9 days after flowering in groundnut (Vara Prasad et al. 2000).

**EXTRAHEAT:**
FLORET MORTALITY, SPIKELET INFERTILITY

Examples of implementation: Rice (ORYZA1, Kropff et al., 1993; SimwRice, Horie et al., 1991); recently: wheat, barley (MONICA, Nendel et al., 2011); ......

Fig. Crop model CROPSYST calibrated for wheat and sunflower (Moriondo et al., 2011)

Algorithm: reducing factor for

\[ HI = \frac{dHI}{dt} \times GF \]

Challinor et al., 2005; GLAM-HTS

Source: Climatic change (2011) 104, p. 687
Extreme Heat: Effect on leaf senescence

(Wheat: Asseng et al., 2011/APSIM-Nwheat in Australia; Lobell et al., 2012; Modis compared to APSIM & CERES, in India)

"Most drastic impact is when Tmax rises > 34°C hastening leaf senescence..."

\[ F_{\text{heat}} = 1 - \frac{1 - (T_{\text{max}} - 34)/2}{1} \]

\[ F_{\text{heat}} = 1 \quad T_{\text{max}} \leq 34^\circ C. \]  

Threshold > 34°C (after, Porter & Gawith, 1999)

Examples of climate and socio-economic data in previous assessment
AgriAdapt projections EU-25
(including assumptions on technology trend (Ewert et al. 2011; Angulo et al. 2012))

Selected projections of Europe-wide yield changes for 2050 under various CC scenarios, CO2 (& tech trend) range from -30 to +35 (> 80) % for cereals; and -10 to +40% for grass

In Nordic countries, corresponding yield changes range from -5 to 20% for cereals and +5 to +40% for grass;

Note: the studies selected/quoted do not take changes in variability (neither in extremes) into account
Climate projections by RCMs for EMTOX project (largely Nordic)

Figure 2. (Colour online). Projected changes in mean summer (June–August) temperature for the scenario period 2031–2050 as compared with the reference period 1975–1994. Note that similar patterns are seen for the five models using the ECHAM5 GCM.

Source: M Sloth Madsen et al., 2012
Two regional pilots for integrating plant-farm-region-sector level:
(1) Cereals-pigmeat (Varsinais-Suomi in South-West Finland);
(2) Grassland-dairy (Pohjois-Savo region),
HAM: objectives and study sites

OVERALL: To examine capability of crop simulation models in quantifying historical adaptation measures (in Finnish barley)

The specific objectives of this study are:

- (i) To quantify trends/shifts in sowing, cultivar use (autonomous adaptation) and their relation to yield changes during 1971-2010 – both, on station and at farms

- (ii) To simulate G x E x M for barley & separate effects of different crop cultivars, sowings (and other management practices) on yield in main cultivation regions

MTT study sites with main barley cultivation areas and Env Zones (Metzger, 2005)
MIROC 3_2 Medres A1B

Sowing date deviation (relative to May 1st)

Rain 3-7 weeks after sowing (early drought stress)

No. of days with Tmax $\geq 28^\circ$C around heading (specific heat stress)

Temperature sum accumulation rate per day at grain filling (yield potential reduction risk)

Source: Rötter et al., in prep
Projected changes in mean temperature and precipitation during March-August for selected stations in Finland

Changes in T and PRECIP for time periods 2011-2040, 2041-2070 and 2071-2100 compared with 1971–2000 for six representative locations relevant for agricultural production in Finland (see Fig.). Six GCMs (CCCMA CGCM 3.1, CSIRO MK 3.5, GISS MODEL E R, IPSL CM4, MIROC 3.2 MEDRES and BCCR BCM 2.0) are presented.

Source: Rötter et al. In prep
Probability density functions of spring barley yields during 1971-2000 and 2071-2100 under selected climate change scenarios at Utti.
Climate sensitivity analysis
(Beyond 4 degrees – spring barley_FI)
(simulations for 2 sites x 2 soils x 1 crop (spring barley))

• Reference period 1971-2000
• ΔT: -2, +2,+4,+5,+6,+7
• Increased CO2 (560 ppm) with +4,+5,+6,+7
• Summer precipitation, daily amounts -40%,-20%,+20%,+40%
• Varying soil moisture conditions in spring
• Set of scenarios applying a weather generator
  – Changes in variation of T: 1.5 and 2.5 x SD
  – Variation of summer rainfall, prolonged periods without rain and longer periods of rainy days with no change of precipitation sum
  – T+4 and decreased probability of wet days
  – T+4, +/-20% precipitation, & prolonged periods...
• SRES scenarios A1F1 and B1 implemented with HadCM3 model
Finland: Crop response to changes in climatic means and variability using a Weather Generator

What would happen to barley production in Finland if global warming exceeded 4 °C? A model-based assessment

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1MTT Agrifood Research Finland, Jokioinen, clay soil
THANKS!