Raport stiintific

privind implementarea proiectului in perioada Decembrie2011 – decembrie 2012

Abordare interdisciplinara a modelarii dinamice a transferului tritiului in plante agricole PN-II-ID-PCE-2011-3-0396

Accidentul de la Fukushima a schimbat profund situatia energeticii nucleare, punand accent pe cresterea sigurantei si diminuarea impactului radiologic. In acelasi timp, un workshop desfasurat la Groeningen, Olanda (Martie 2011, http://www.math.rug.nl/stat/models/) atragea atentia asupra calitatii slabe a modelelor folosite in multe domenii privind luarea deciziei in cazul urgentelor nucleare. Ca urmare, forurile internationale au cerut nu numai intarirea sigurantei reactorilor nucleari, dar si imbunatatirea modelelor de evaluare a impactului radiologic. Agentia Internationala de Energie Atomica (AIEA Viena) a decis continuarea si cresterea activitatilor in domeniu si coordonarea unui program, MODARIA (MOdelling and DAta for Radiological Impact Assessment) (2012 – 2016, http://www-ns.iaea.org/projects/modaria/default.asp?s=8&l=116), dedicat cresterii capacitatii tarilor membre pentru achizitia de date si dezvoltarea de modele radiologice. In acest proiect, se continua activitatea grupului "Accidental Tritium Release" sub conducerea Dr. D. Galeriu, directorul acestui proiect de IDEI EXPLORATORII. Strategia de dezvoltare a proiectului a fost re-orientata in vederea decelarii surselor de incertitudine si elaborarii unui model apropiat necesitatilor practice. Aceasta presupune largirea bazei de cunoastere a proceselor ce intervin in transferul tritiului, asimilarea modelelor folosite in diferite stiinte ale vietii si mediului si alegerea variantei optime ca dimensiune a complexitatii si accesibilitatii parametrilor de model. Meteorologia, interactia atmosfera-vegetatie, procesele de crestere a plantelor si rolul apei din sol sunt de interes major, ca si baza de date privind parametrii caracteristicilor culturilor si solurilor din regiunea Cernavoda. Progresele inregistrate in perioada raportarii sunt sumarizate in prezentul raport.

Revizia datelor experimentale privind formarea tritiului legat organic in plante agricole este absolut necesara pentru intelegelerea proceselor si alcatuirea bazei de date pentru dezvoltarea si verificarea modelelor. Un articol a fost publicat in 2012, in cadrul proiectului.

Testarea modelului precedent cu date experimentale pentru graul de toamna.
Experimente nepublicate au fost folosite in intercompararea modelelor si raportate in Documentul tehnic EMRAS II "Tritium Accidents". Exemplul este un caz favorabil si demonstreaza ca IFIN-HH se situeaza foarte bine.

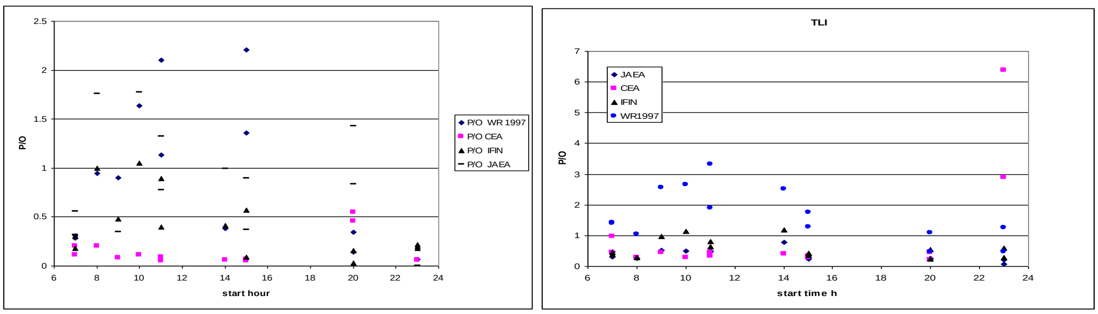


Figura 1. Raportul estimat/observat pentru concentratia de OBT in frunze la sfarsitul expunerii (stanga) si indexul de translocare (dreapta)

Stabilirea pasului temporal al modelarii Prin amabilitatea unor cercetatori germani am primit datele experimentale nepublicate privind contaminarea cu tritiu a graului impreuna cu evolutia detaliata a concentratiei de HTO in aer, temperatura, radiatie solara, umiditate relativa si concentratia de CO_2 in incinta experimentala. Modelul preliminara al IFIN-HH a fost rulat cu medii orare si medii pe 10 minute, iar predictiile au fost comparate cu rezultatele experimentale (Figura 2). Un pas temporal mai fin determina o predictie mai buna pentru HTO in frunze, dar nu este esential pentru OBT in frunze. Includerea dependentei de CO_2 este necesara. Frunzele au nevoie de 15-25 minute ca sa se adapteze la schimbari de mediu. Ca urmare, pasul temporal pentru modelul nou este cuprins intre 20 minute si maxim o ora.

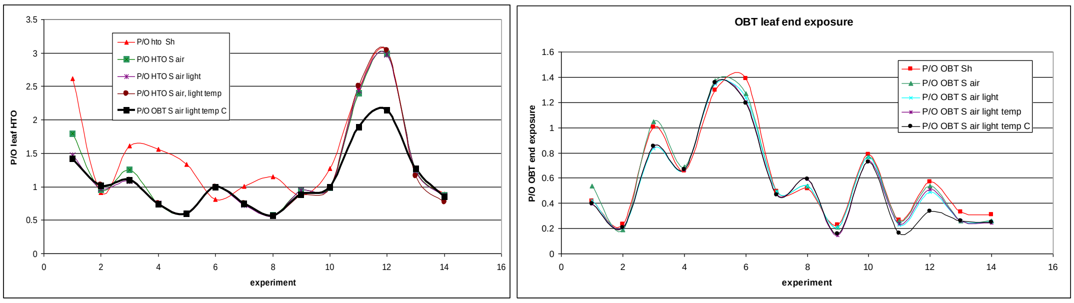
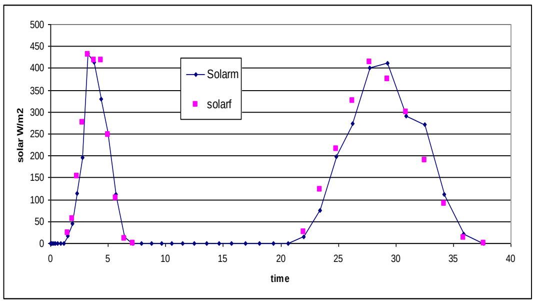


Figura 2. Raportul estimat/observat pentru concentratia de HTO (stanga) si OBT in frunze (dreapta) la sfarsitul expunerii

Datele meteorologice reale caracteristice zonei de aplicare a modelului trebuie sa satifaca cerintele meteorologiei nucleare in regim de urgenta. Sistemul de supraveghere meteorologica al IFIN-HH asigura o baza de plecare si se dezvolta pentru a corespunde cerintelor (http://meteo.nipne.ro). Din alte surse de finantare, s-au achizitionat senzori meteo de calitatea ceruta si din acest proiect s-au comandat dispozitivele de prindere pe turn corespunatoare standardelor moderne. Un program de asigurarea calitatii este in curs de desfasurare. Sunt conditii ca in 2013 sa avem date continue si de calitatea necesara si experienta IFIN-HH sa fie transferata la CNE Cernavoda.

Predictia metorologica orara pe termen scurt (2-3 zile) Atat in timpul accidentului, cat si urmatoarele doua zile, datele meteorologice orare sunt esentiale pentru prognoza dinamicii tritiului in plante si sol. Prognoza pe termen scurt data de centre specializate consta in predictii cu un pas orar de 3 sau 6 zile pentru temperatura, umiditatea relativa, cantitatea totala de precipitatie pe interval, viteza si directia vantului si gradul de acoperire cu nori al cerului. Aceste predictii se interpoleaza pentru a avea date orare. Probabilitatea de realizare a predictiilor depinde de profesionalismul centrelor de prognoza. O statistica internationala situeaza pe primul loc Meteorologia Nationala a Norvegiei (cu exceptia precipitatiilor). Am primit acordul de a accesa automat si gratuit aceste predictii (pentru un interval de 6 ore) si in caz de necesitate, si accesul la predictiile pe un interval de 3 ore. Compararea cu datele masurate ulterior am facut-o de cateva ori pe luna (incepand cu Martie 2012) si demonstreaza ca datele IFIN-HH sunt suficient de precise pentru scopurile noastre. Pentru a obtine date prognozate pentru radiatia solara, am folosit predictia gradului de acoperire cu nori si modele testate pentru radiatia solara. Pentru alegerea modelului, s-au consultat rezultate recente si s-au comparat cu masuratorile locale de-a lungul ultimilor 2 ani. Modelul adoptat include variatia lunara a turbiditatii atmosferei si gradul local de poluare generala (industrial, rural, etc). Comparatia intre prognoza si datele masurate ulterior este data in Figura 3 pentru radiatia solara si temperatura, pentru perioada 5 Noiembrie 2012 ora 0 - 6 Noiembrie 2012 ora 18.



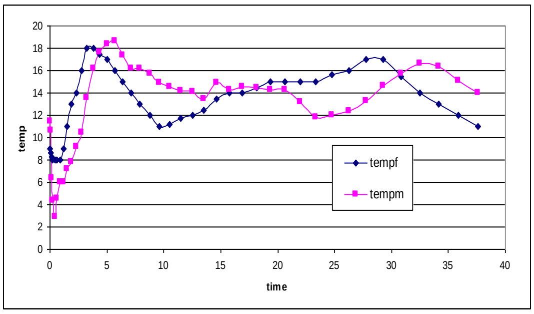


Figura 3. Comparatia intre prognoza si datele masurate pentru radiatia solara (stanga) si temperatura (dreapta)

Rezultatele obtinute sunt in acord cu cerintele de calitate ale modelarii si vor fi aplicate.

Predictia metorologica zilnica pe termen lung Aceasta este necesara pentru prognoza cresterii plantelor si a dinamicii apei in sol, precum si pentru informatiile necesare modulului TRITIU. Predictia meteorologica zilnica pe termen lung livreaza valorile probabile zilnice pentru precipitatie, radiatie solara, temperatura minima si maxima, umiditatea relativa. Aceste predictii trebuie sa corespunda si cu frecventa claselor de precipitatie din zona. Ele se bazeaza pe statistica ultimilor ani, perturbata in acord cu predictia generata de Meteorologia Nationala si Internationala, pentru urmatoarele luni (relativa la un an normal). Statistica pe ultimii ani se obtine din date locale sau preluate de la Meteorologia Nationala. Dispunem de date IFIN-HH si CNE Cernavoda pe perioada 2010-2012 si am achizitionat date pentru Bucuresti pe ultimii 5 ani; de asemenea, date mai vechi de la Fundulea. Aceste informatii le folosim pentru a asimila codurile specifice de generare a vremii. Am folosit CLIMGEN si WGEN, din generatia ‘80- ‘90 pe care le avem deja asimilate. Datele generate nu corespund cu clasele de precipitatie si nu sunt utile scopului proiectului. In prezent, am primit literatura si coduri recente care pot rezolva problema pe baza asimilarii datelor pana in trimestrul I 2013 (inclusiv).

Baza de date pentru culturi agricole si sol S-au actualizat categoriile de culturi predominante in zona Cernavoda si ne vom concentra pe porumb, grau, floarea soarelui, soia, vita de vie, legume frunzoase si cu fructe, pasune. Caracteristicile fenologice ale genotipurilor actuale de porumb au fost stabilite de noi pe baza datelor experimentale. Pentru celelalte culturi, actiunea e in desfasurare. Pentru sol, vom accesa baza de date nationala, deoarece proprietatile solului variaza lent si datele obtinute in 1980-2010 sunt suficiente.

Modele pentru starea actuala a culturilor si prognoza pe toata durata de vegetatie

In trecut am folosit intensiv modelul WOFOST (dezvoltat de Scoala de la Wageningen, Olanda), agreat de UE, pentru descrierea cresterii plantelor agricole. Am utilizat date experimentale despre genotipurile romane (anii 1980-1994) si am adaptat modelul la conditiile specifice zonei de interes . Pentru proiectul de fata, WOFOST este transformat ca o subrutina a modelului dezvoltat de noi care se executa automat. WOFOST nu satisface complet cerintele proiectului actual si am asimilat mai multe modele recente: AQUACROP (FAO 2011), SWAP (Altera 2012), DSAAT4.5 (ICASS 2012). Autorii acestor modele ne-au acordat licenta de a folosi si MODIFICA-ADAPTA parti din modele pentru scopurile proiectului de fata.

Modelarea evapotranspiratiei in conditii ideale si reale, este o necesitate stringenta a proiectului. Pentru evapotranspiratia potentiala am investigat modelele standard din stiintele agricole (FAO 2011) pentru pas temporal de o zi sau o ora. Modelul cu pas de o zi este in acord cu suma orara, si confirma rezultatele din literatura. Am analizat si procesul pe componenta de radiatie si de fortare atmosferica si am observat mari neconcordante ce provin din erori compensatorii si ignorarea separarii corecte a contributiei solului si vegetatiei. Pentru proiectul de fata am adoptat un model mai fizic (Shuttleworth-Wallace) dar mai complex, care s-a impus recent in cercetarile privind interactia atmosfera-suprafata. Modelul a fost extins de noi si in cazul tritiului si va fi folosit in proiect. Sunt necesare unele imbunatatiri privind efectul precipitatiei si conservarea energiei in complexul vegetatie-sol, cat si a efectului stresului hidric.

Modelarea interactiei radiatie – vegetatie Pentru modelarea radiatiei solare (pozitia soarelui si iradierea directa/difuza) am consultat modele complexe (NOAA) dar si modele de complexitate mai redusa (SolarCalc, SolarCalQ, solradV16). Pentru proiectul de fata, am dezvoltat un model practic, cu minim de date de intrare, dar care reproduce modele compexe cu precizie 2%. O revizie completa a literaturii recente a relevat necesitatea unor tratari mai precise privind partitia luminii solare in radiatie difuza si directa, cat si a interactiei cu vegetatia (reflexie, transmisie, absorbtie). Pentru fractia difuza adoptam Skartveit & Olseth (Figura 4 - stanga), care reproduce cel mai bine observatiile experimentale. In cazul interactiei cu vegetatia, retinem modelul Goudrian & van Laar (dreapta), care da rezultate foarte apropiate de modelul exact, dar cu timp de calcul redus. In acelasi timp, se evidentiaza necesitatea distingerii intre frunzele direct insorite (SU) si cele din umbra (SH). Dependenta de inclinarea funzelor (intre 30 si 60) nu este puternica.

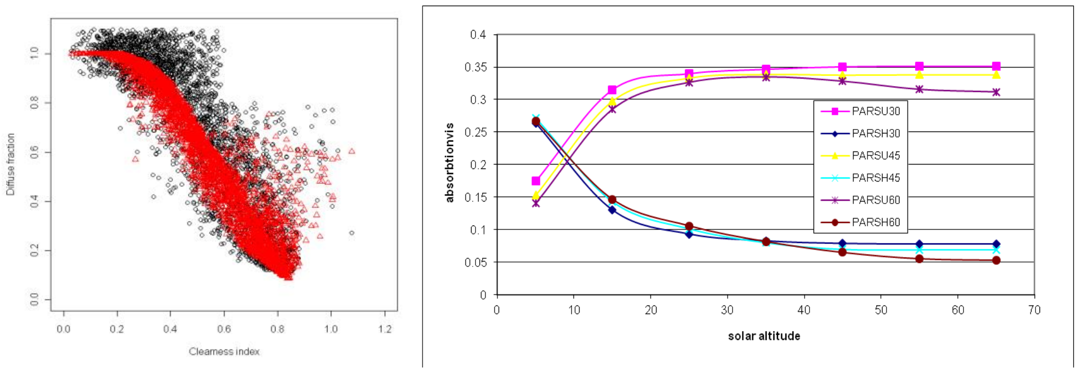


Figura 4. Partitia luminii solare in vegetatie: fractia difuza (stanga) si fractia directa (dreapta)

Modelarea dinamicii apei in sol, reprezinta una din problemele dificile ale proiectului deoarece trebuie sa raspunda unor situatii extreme - seceta prelungita, dar si ploi intense care satureaza solul. In aceste conditii, rezolvarea matematica a ecuatiilor de transfer in sol – apa si apa tritita, este mai dificila iar cunoasterea proprietatilor hidraulice ale solului (pedofunctii) este limitata. O revizie a literaturii recente a fost facuta, cat si elaborarea unor subprograme. Actiunea se va continua pana la alegerea solutiei optime.

Modelarea fotosintezei in plante agricole este necesara pentru cresterea plantelor (materie uscata), formarea tritiului legat organic, dar si pentru modelarea transferului atmosfera-frunze (viteza de schimb). Modelele care au fost deja asimilate (Marshal & Biscoe, Colatz C3, Colatz C4, Jacobs) au fost comparate cu modelul folosit de noi si preluat din WOFOST si nu aduc elemente substantial noi. Mai recent, in literatura de specialitate s-a impus un model complex biochimic -revised Farquhar (Yin et al.2004. Plant, Cell & Environment 27:1211-1222, Bonan 2012). Aceste modele fac nu numai distinctia intre frunze insorite si umbrite, dar detaliaza si alte procese. Implementarea-asimilarea lor este in curs, pentru a decela potentialele influente asupra incertitudinii finale.

Transferul tritiului atmosfera-sol-plante se face dupa ecuatiile proprii (extinderea modeluui Shuttleworth & Wallace), in care rezistenta aparatului foliar este determinata de fotosinteza si deficitiul de vapori de apa si apa din sol. Pentru apa tritiata din sol se rezolva ecuatii specifice bazate in esenta pe dinamica apei in sol (cu dificultatile enumerate mai sus).

Formarea tritiului legat organic se modeleza dupa mecanisme compexe in care se face distictia intre formarea in timpul zilei si in timpul noptii. In cazul formarii numai in timpul zilei, se aplica formalisme agreate international, dar pentru formarea in timpul noptii nu exista inca un model adecvat. In cadrul proiectului se incerca elaborarea unui model bazat pe distinctia intre dinamica produsilor de fotosinteza solubili si insolubili, cat si pe detalierea proceselor de respiratie.

Dezvoltarea prototipului se face gradat, pentru fiecare sub-proces in parte. Se preconizeaza ca prototipul sa fie gata in trimestrul II 2013 si primele teste sa fie facute inainte de August 2013. Pentru prognoza vremii pe timp lung, noile abordari vor fi gata anul acesta, urmand sa ne concentram ulterior asupra dinamicii apei in sol-radacina si formarii tritiul in timpul noptii. Pentru celelalte aspecte nu sunt probleme conceptuale, dar implementarea noilor formalisme de fotosinteza necesita un efort de durata.

Diseminare

D. Galeriu, A. Melintescu, S. Strack, M. Atarashi-Andoh, S.B. Kim, "An overview of organically bound tritium experiments in plants following a short atmospheric HTO exposure", *J. Environ. Radioactiv.* (2012), 10.1016/j.jenvrad.2012.11.005.

A. Melintescu, D. Galeriu, S. Tucker, P. Kennedy, F. Siclet, K. Yamamoto, S. Uchida, "Carbon-14 transfer into potato plants following a short exposure to an atmospheric $^{14}CO_2$ emission: observations and model predictions", *J. Environ. Radioactiv.* (2012), DOI: 10.1016/j.jenvrad.2012.08.005, 2012

D. Galeriu, A. Melintescu, "Research and development of environmental tritium modelling – an update", 57th Annual Meeting of the Health Physics Society, 22-26 July 2012, Sacramento, California, USA, follow to be published in *Health Physics INVITED LECTURE*

D. Galeriu, A. Melintescu, A. Gheorghiu, "Environmental modeling for nuclear safety – the case of tritium", 2nd European Nuclear Physics Conference, September 17-21, 2012, Bucharest, Romania (see http://www.nipne.ro/indico/contributionDisplay.py?contribId=65&sessionId=12&confId=0)

D. Galeriu, A. Melintescu, "Environmental modelling for tritium safety", National Workshop on Tritium Management "International and National Experience and Lessons Learned Related to Designing and Operation of Tritium Removal Facility", June 6-8, 2012, Rm-Valcea, Romania

A. Melintescu, D. Galeriu, "Open problems in OBT modelling in crops", 1st Workshop on OBT (Organically Bound Tritium) and its analysis, Balaruc les Bains, France, 21-24 May 2012 (see http://www.obt2012.com/?page_id=10), available at: http://www.wdcbo.com/1205_OBT/120523_0930.pdf

D. Galeriu, A. Melintescu, "Briefing of experimental knowledge of OBT in plants", 1st Workshop on OBT (Organically Bound Tritium) and its analysis, Balaruc les Bains, France, 21-24 May 2012 (see http://www.obt2012.com/?page_id=10), available at: http://www.wdcbo.com/1205_OBT/120523_1000.pdf

IDEI EXPLORATORI

Abordare interdisciplinara a modelarii dinamice a transferului tritiului in plante agricole

PN-II-ID-PCE-2011-3-0396

Director proiect Dr. D Galeriu

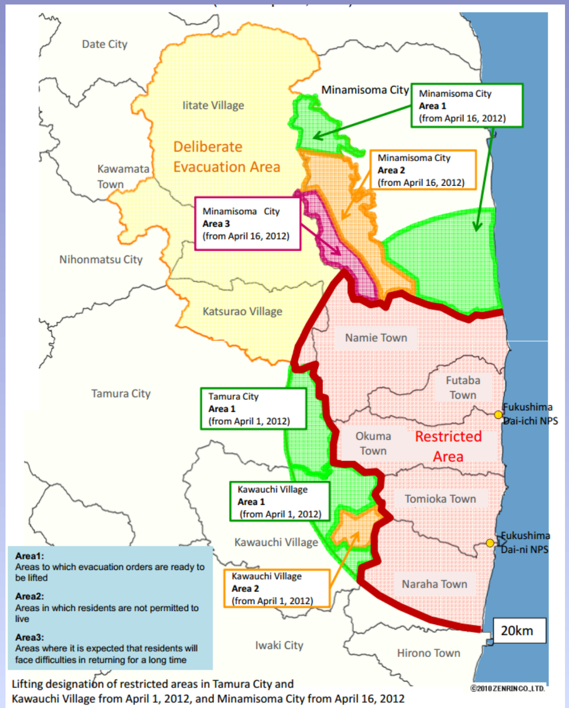
Dr. A Melintescu, Dr. C. Lazar*, A. Gheorghiu, B Zorila….

And much mores spread on continents

NOTA: suport romanesc al contributiei IFIN-HH la
IAEA-MODARIA **Modelling and Data for Radiological Impact Assessments Working Group 7 — Harmonization and intercomparison of models for *accidental tritium releases***
WG leader - marca 283 IFIN-HH Romania

*Institutul National de Cercetare Agricola Fundulea

Justification



Fukushima Daiichi Status Report

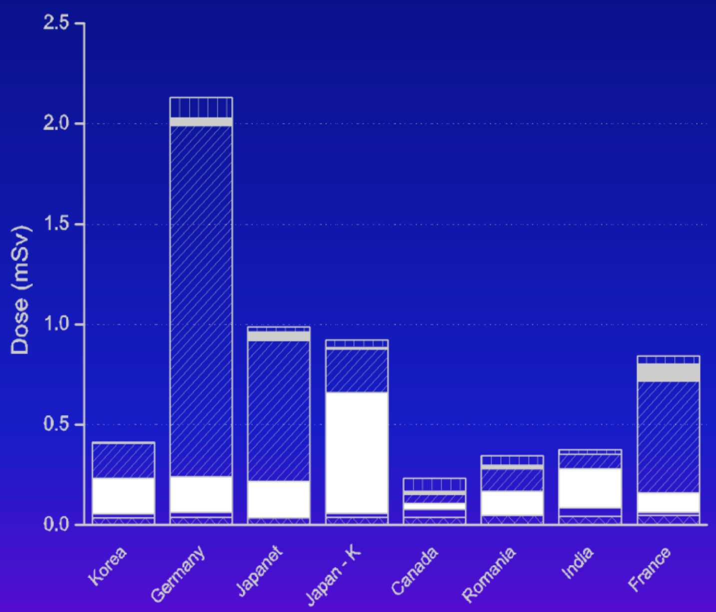
Stress on nuclear energy

IAEA MISSION

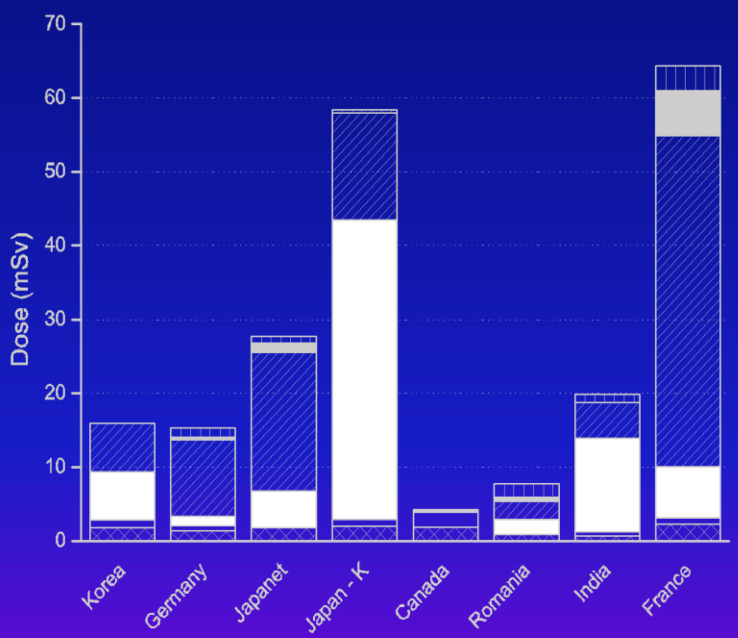
MODARIA goals

HYPO scenario EMRAS I
1 h HTO emission 10 g
at 1 km from stack

- **Case 1 day** Normalized by 6.10[9] Bq.s.m[-3]

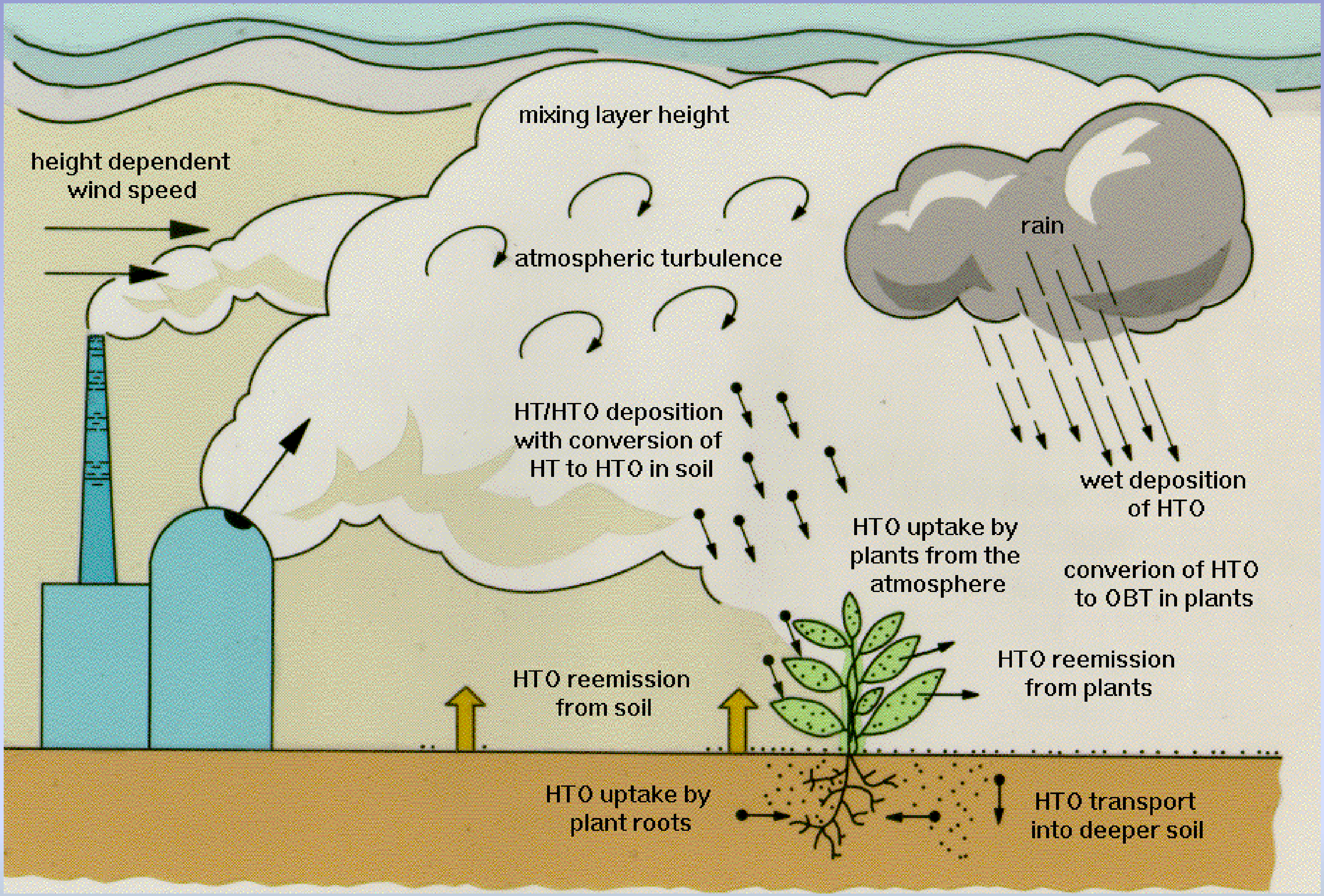


- **Case 3 night** Normalized by 3.10[11] Bq.s.m[-3]



Too large uncertainty. Greenpeace will be happy. Not me

Tritium behaviour into the environment distinguishing between chemical forms



MODARIA – WG7 extract, 2012

- The dynamics of tritium in the terrestrial environment are the result of the complex interaction of a number of processes that are subject to hourly, daily and annual variations. Due to the uncertainties of the environmental conditions at the time of the release, predictions are inherently associated with considerable uncertainties. The work performed in the previous IAEA model testing and comparison programmes improved the understanding of many processes related to tritium washout and transfer in aquatic food chains as well as, to some extent, its transfer in the terrestrial food chain. More work is needed to enable reliable assessments of exposures related to accidental tritium releases taking into account actual weather, environmental and agricultural conditions

Regulatory requirements for a model

- Relatively simple
- Transparent
- Easy to program
- Results should be conservative (but not too much)
- Deterministic calculations possible (worst case assessments)
- Probabilistic calculations possible (95% percentile as the worst case)
- Is this possible for Tritium?

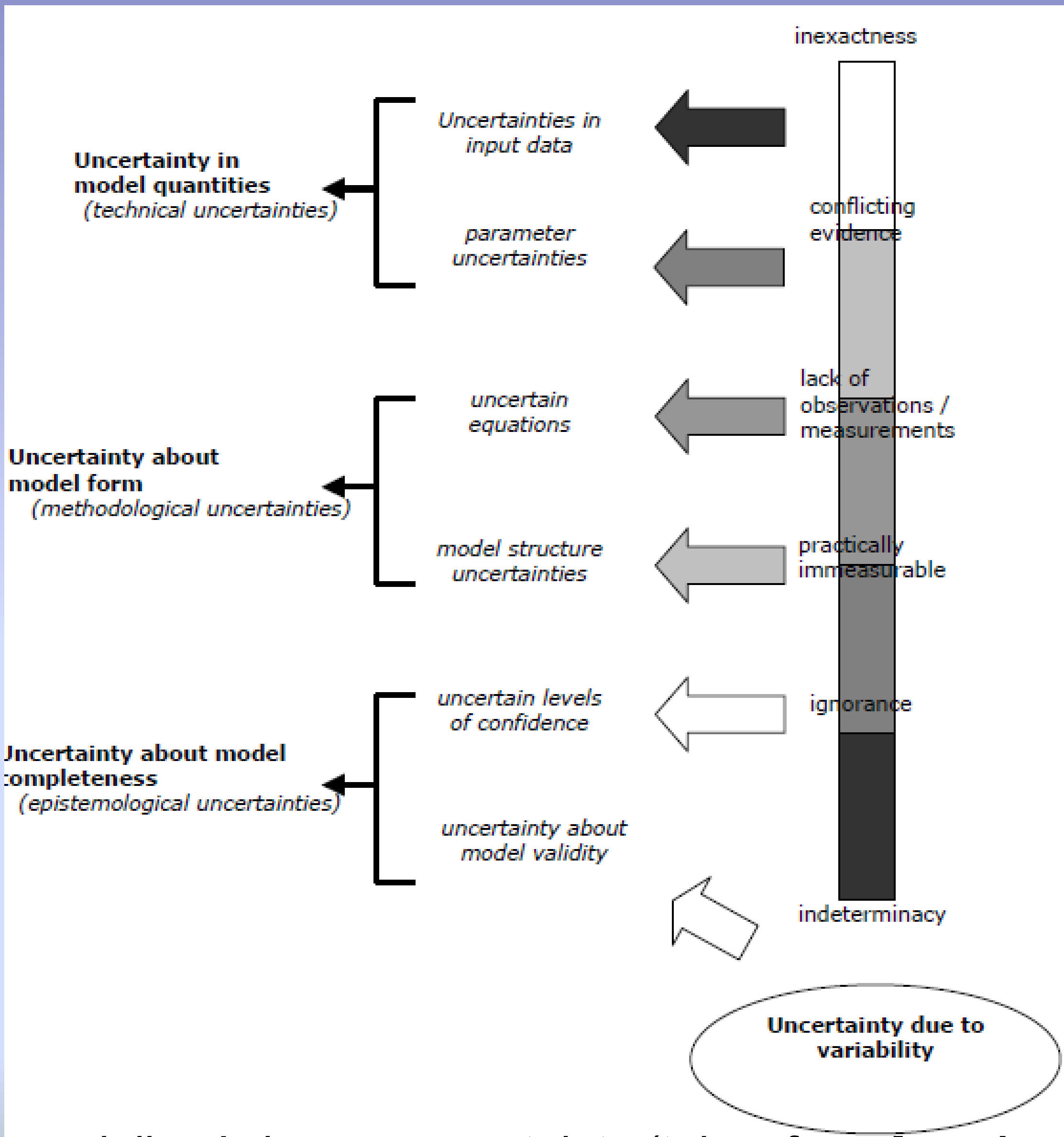
From W Raskob 2010

[?] MODEL

- Un obiect (sistem) A este un **model** al unui obiect (sistem) B pentru un observator C dacă acesta îl poate folosi pe A pentru a răspunde la anumite întrebări privitoare la B [Simota şi Canarache; 1988].

- Într-un model este sintetizată concepţia noastră despre sistem.

Surse de incertitudine in model



COMPENSATORY ERRORS

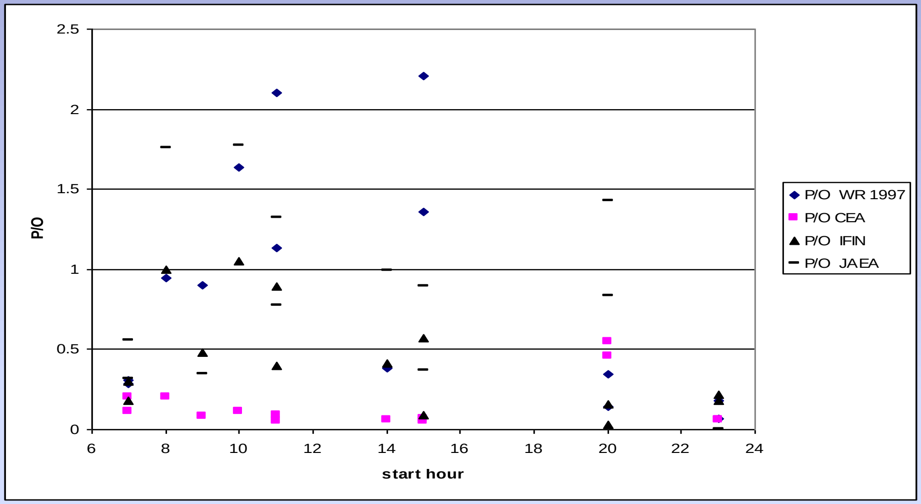
USER INFLUENCE

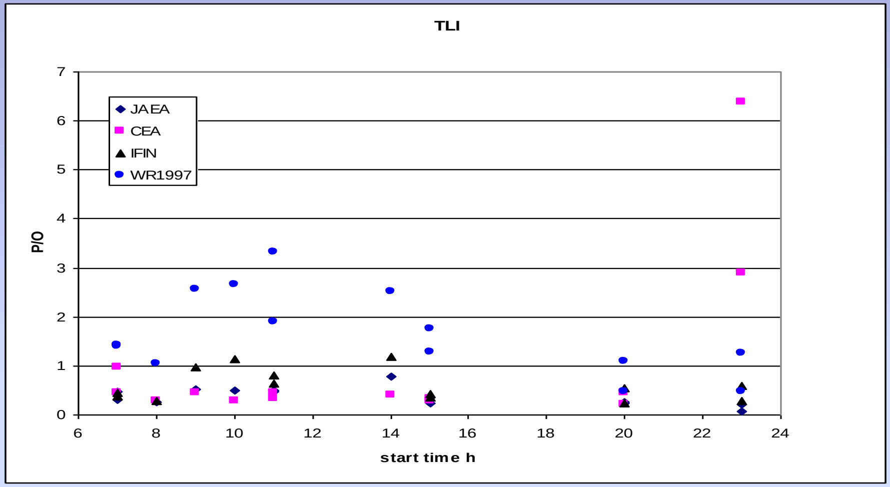
Din BIOMOVS II 1995

A modellers' view on uncertainty (taken from [van Asselt 1999])

Testarea modelului precedent cu date experimentale pentru graul de toamna

cazul cel mai simplu-perioada de umplere liniara





Raportul estimat/observat pentru concentratia de OBT in frunze la sfarsitul expunerii (stanga) si indexul de translocare (dreapta)

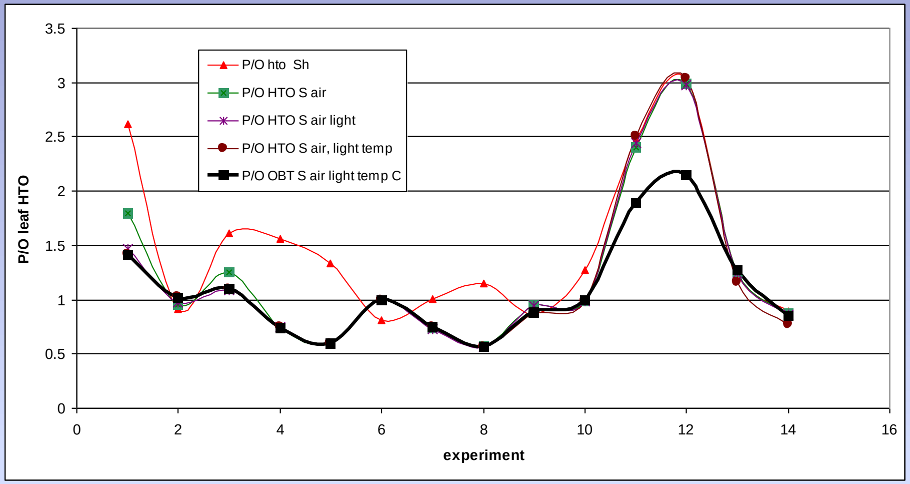
W Raskob Plant-OBT 1997

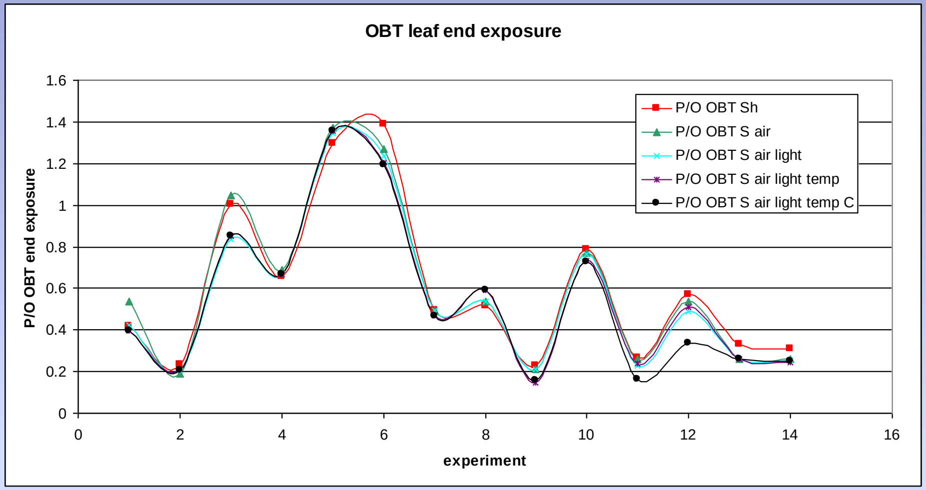
CEA CERES TRITIU 2007-2011

JAEA SOLVEG-H3 2011

IFIN-HH FDMH+ 2005

Stabilirea pasului temporal al modelarii





Raportul estimat/observat pentru concentratia de HTO (stanga) si OBT in frunze (dreapta) la sfarsitul expunerii

Date de intrare ca medii orare si cu considerarea mediilor pe 10 minute

Pentru HTO in aer, radiatie solara, temperatrura si umiditate,concentratia de CO_2 in incinta

Date experimentale nepublicate (S. Strack & S. Diabate)

Modelul IFIN-HH precedent (RODOS FDMH modificat in 2005)

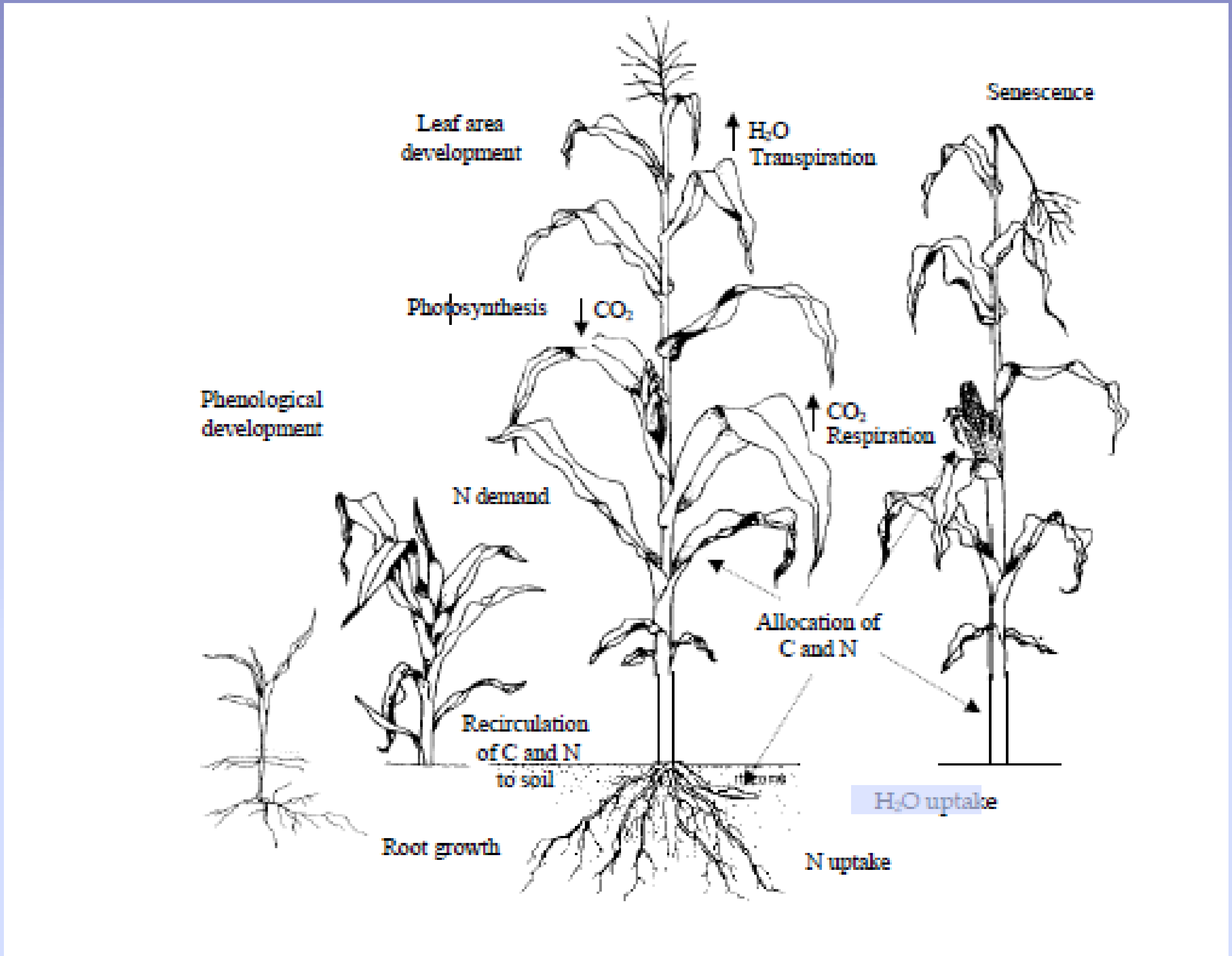
Includerea dependentei de CO_2 este necesara. Frunzele au nevoie de 15-25 minute ca sa se adapteze la schimbarile de mediu. Ca urmare, pasul temporal pentru modelul nou este cuprins intre 20 minute si maxim o ora

H3 and H

- Mass difference 3 to 1> diffusion 1.67
- Transfer leaf air discrimination factor 0.9-0.95
- Biochemical reactions for dry matter-discrimination factor 0.6-0.9, experimental values
- UNDERSTANDING H first
- Organic H exchangeable, firmly bound

(link with C)

- Diffusion: HTO its own gradient , not H_2O



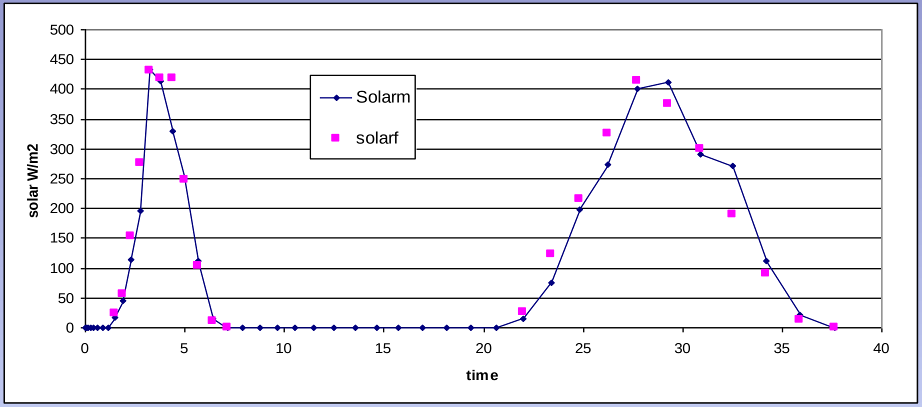
drawings taken from MEIER, ed., 2001

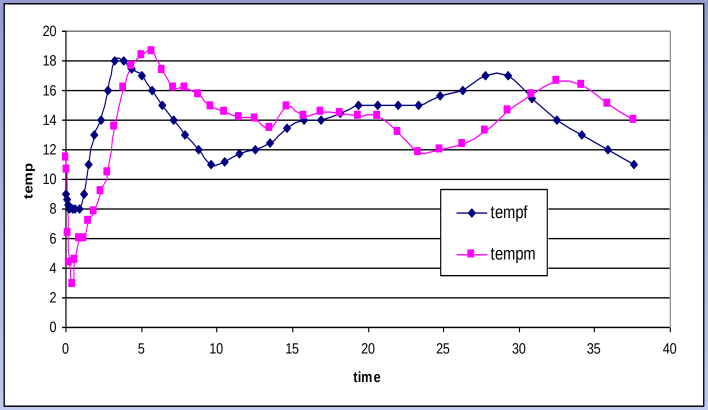
The conceptual model

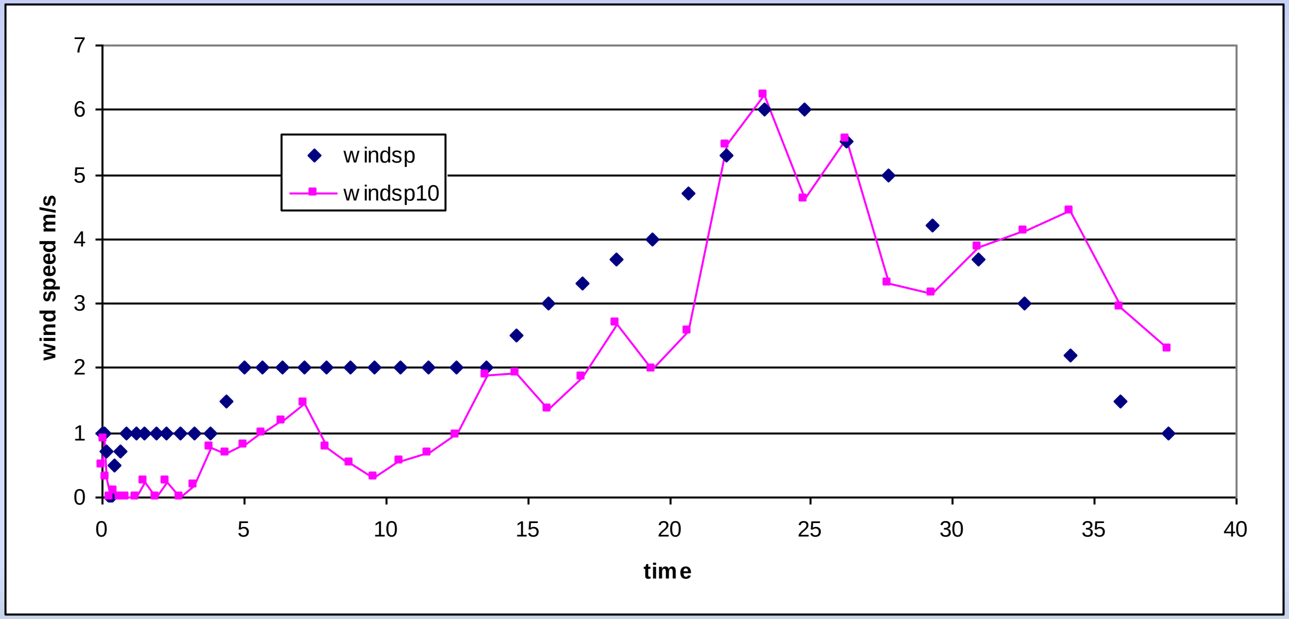
- **Meteorology (perfect data up to start, robust hourly forecast for 3 day, credible daily prognosis for one year after)**
- **Sites local data (positions, area, orography, land use, crops, soils, local production&consumption, import&export of contaminated food)**
- **Crops status and prognosis (models OR/AND remote sensing)**
- **External HTO air concentration dynamics (import from others)**
- **Short term crop tritium modeling (2-3 days after stop exposure)**
- **Long term crop tritium modeling (at least one year)**
- **Cycle on crops and sites**
- **Animal products**
- **Human intake**
- **Uncertainties**

- AMBITIOUS , no chance until end project
- Last step…. Operational at CENAVODA
- Needs collaboration between Romanians…???!!!!

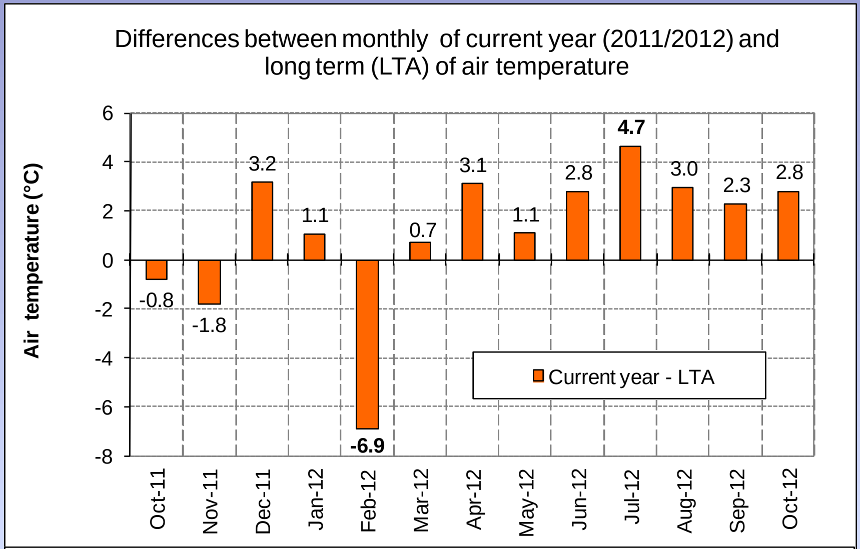
Forecast 3 days (as in 4 Nov 22:00)

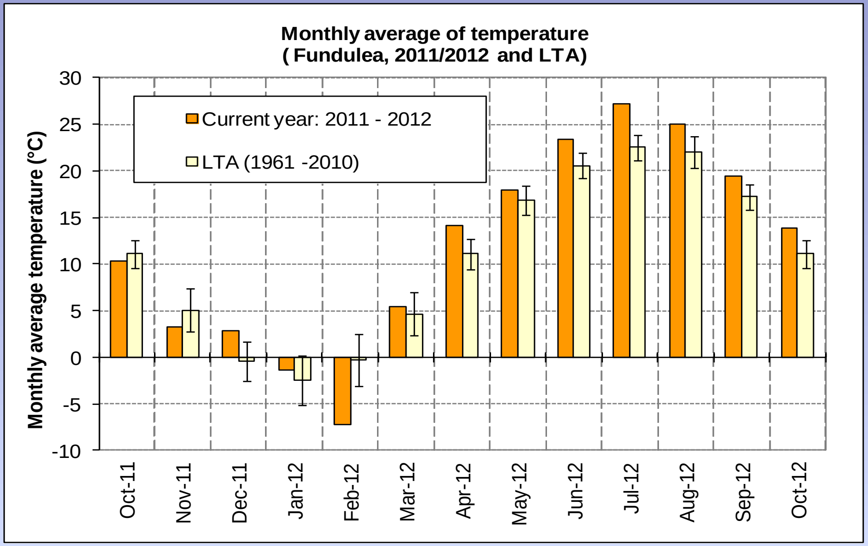


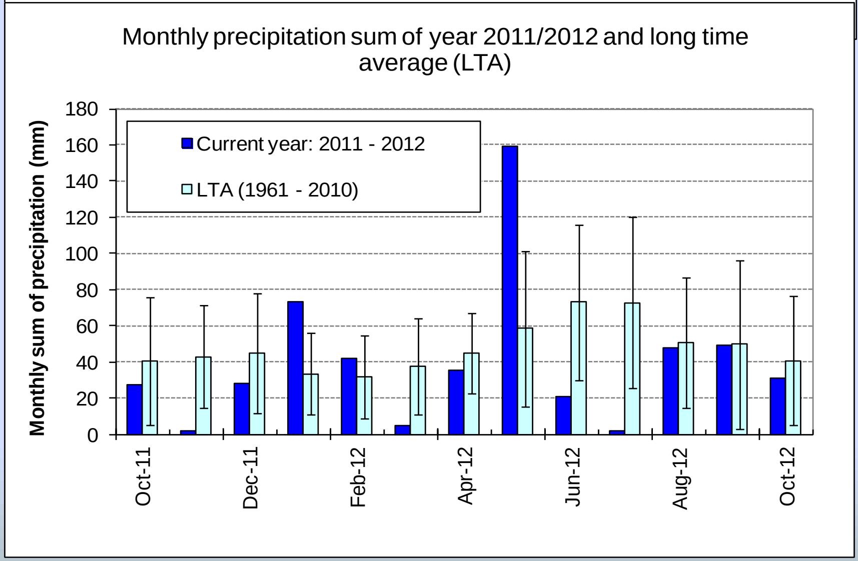


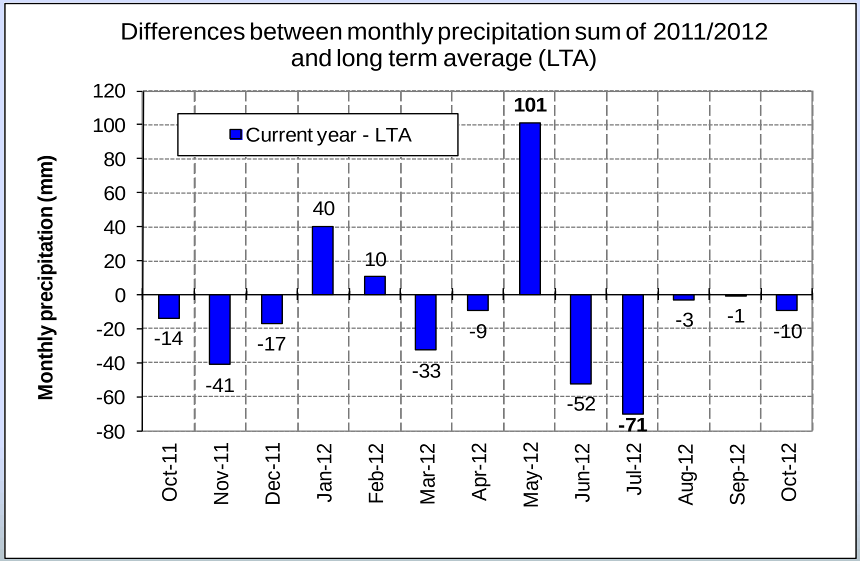


Date meteo locale si sistematica din trecut> Generarea vremii probabile





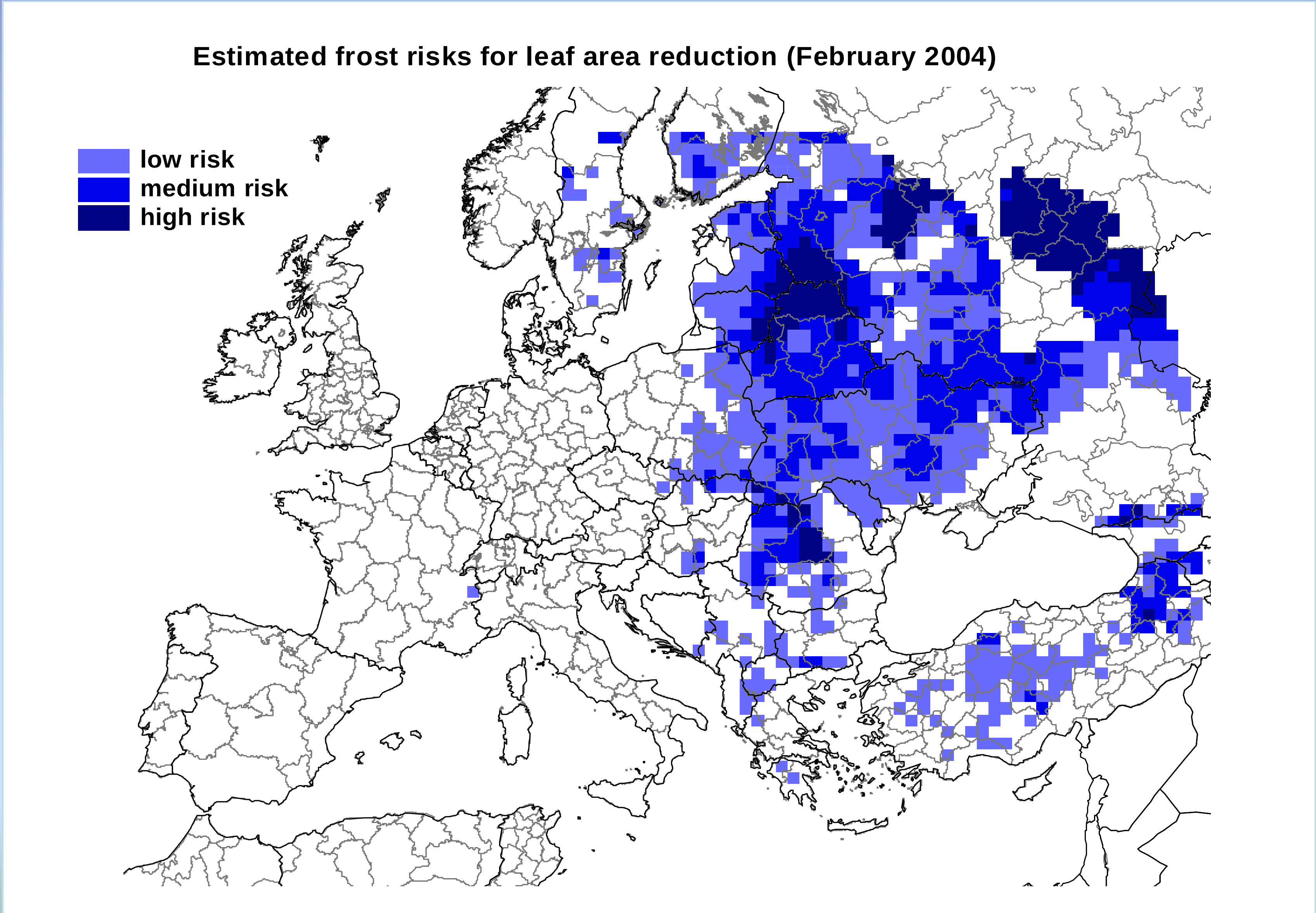




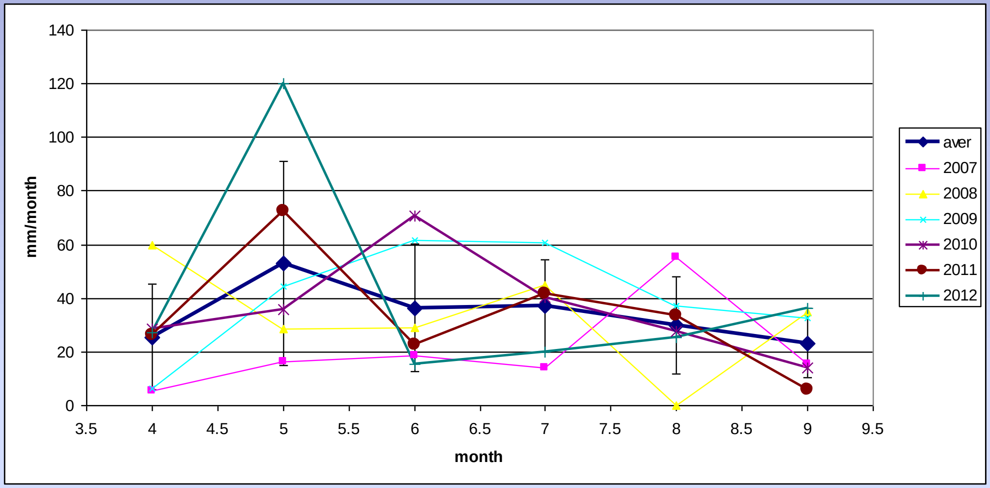
Date Fundulea Catalin Lazar

•Singura metodă utilizabilă în multe studii legate de schimbări climatice

[Condiţii defavorabile şi evenimente extreme] Ieşiri ale subrutinei de GER: Reducerea suprafeţei foliare

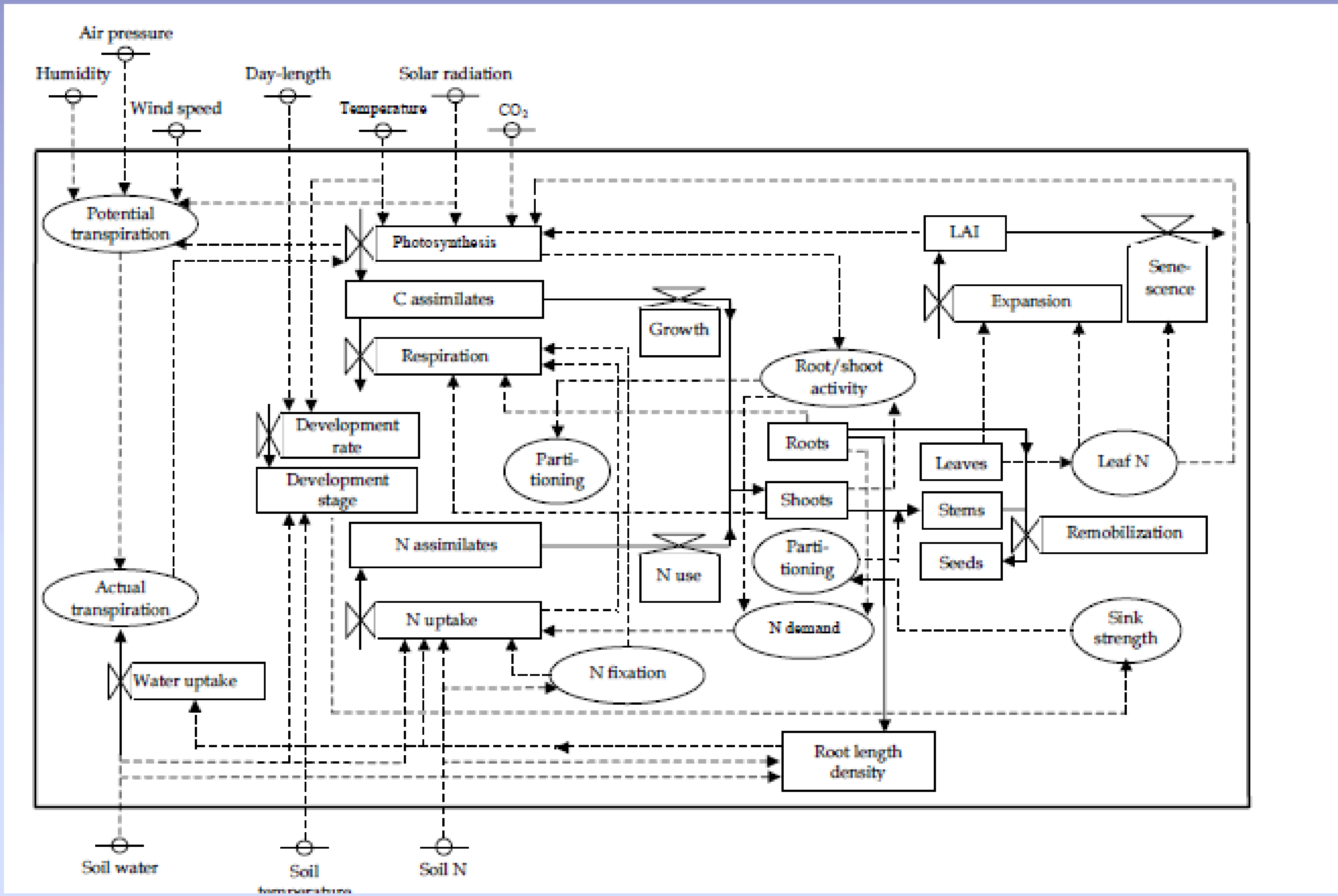


NOT only daily precipitation but also precipitation INTENSITY



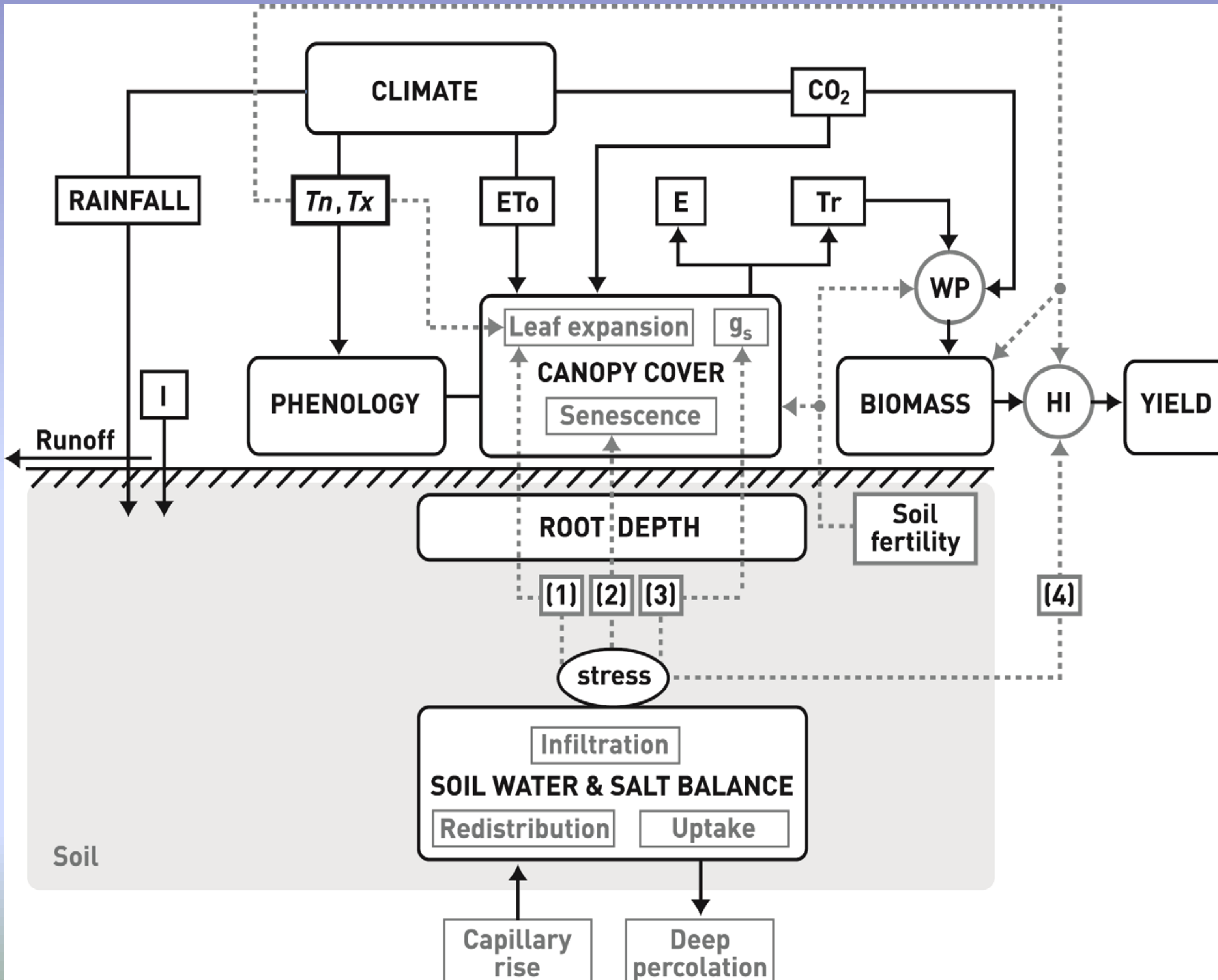
prec 0.1-1 mm/h	0.7699
prec 1-3 mm/h	0.1995
prec 3-10 mm/h	0.0258
prec >10 mm/h	0.0046

Crops   STATE OF THE ART, no tritium

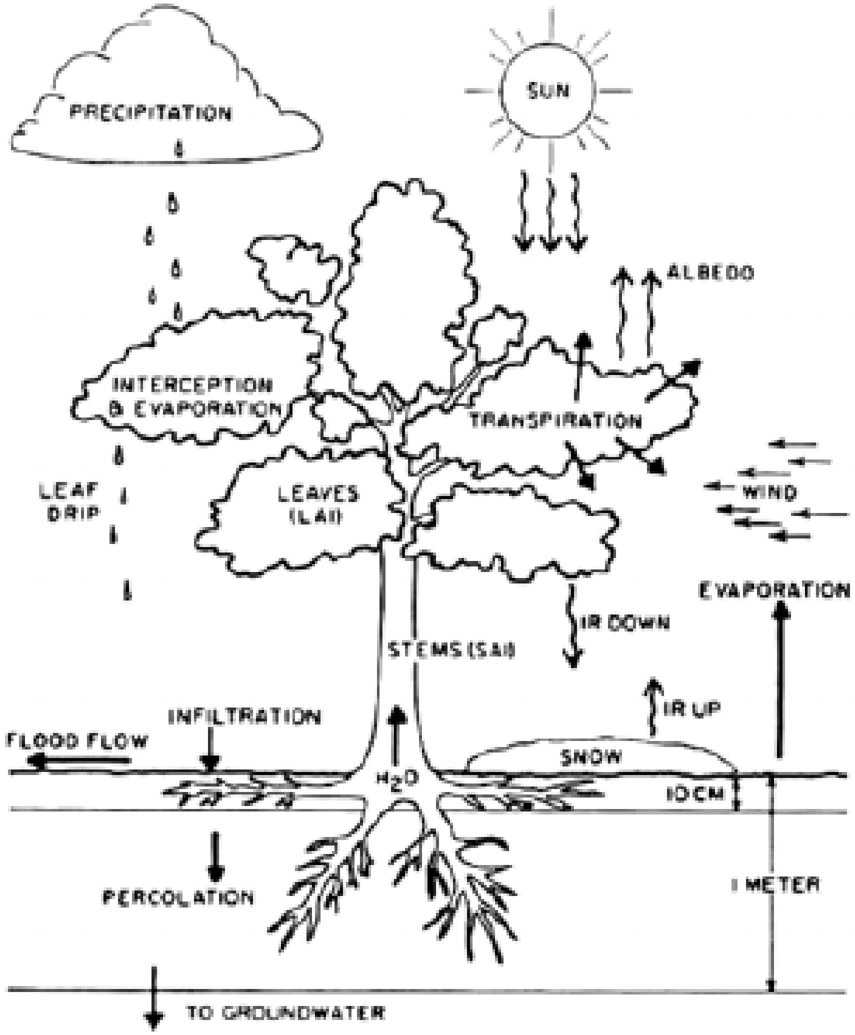


Relational diagram of the DANUBIA crop growth model, based on the diagram of the model GECROS (YIN & VAN LAAR 2005). Symbols introduced by FORRESTER (1961) are used: boxes for state variables, valves for rate variables, ellipses for intermediate variables, small crossed circles for environmental variables, full-line arrows for material flows and dashed-line arrows for information flows.

Crops AQUACROP- minimum model

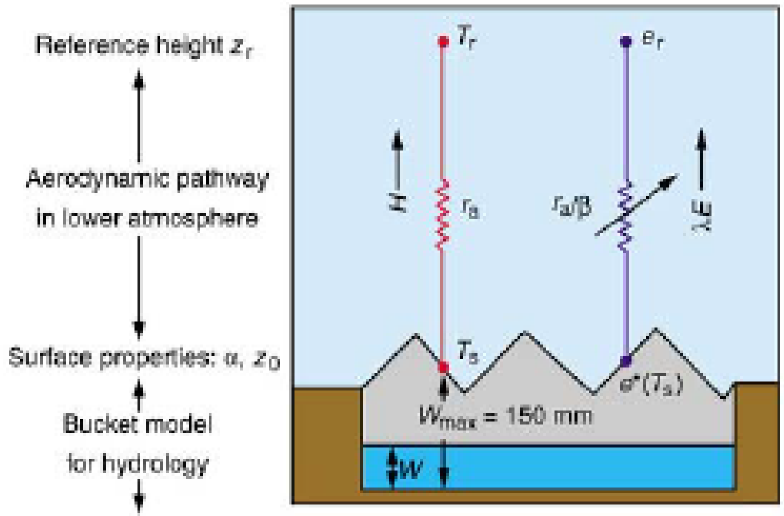


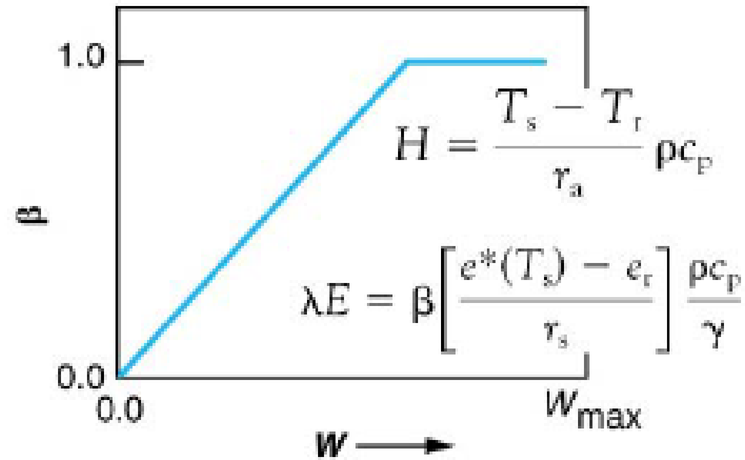
Land-Surface Fluxes



- Radiation and turbulence strongly affected by plants
- Rain and/or snow fall on canopy and/or ground
- Runoff occurs when rate of throughfall exceeds that of infiltration
- Evaporation of stored water on either surface
- Evaporation from near-surface soil (~2 cm)
- Transpiration from root zone through plants
- Percolation and drainage to groundwater

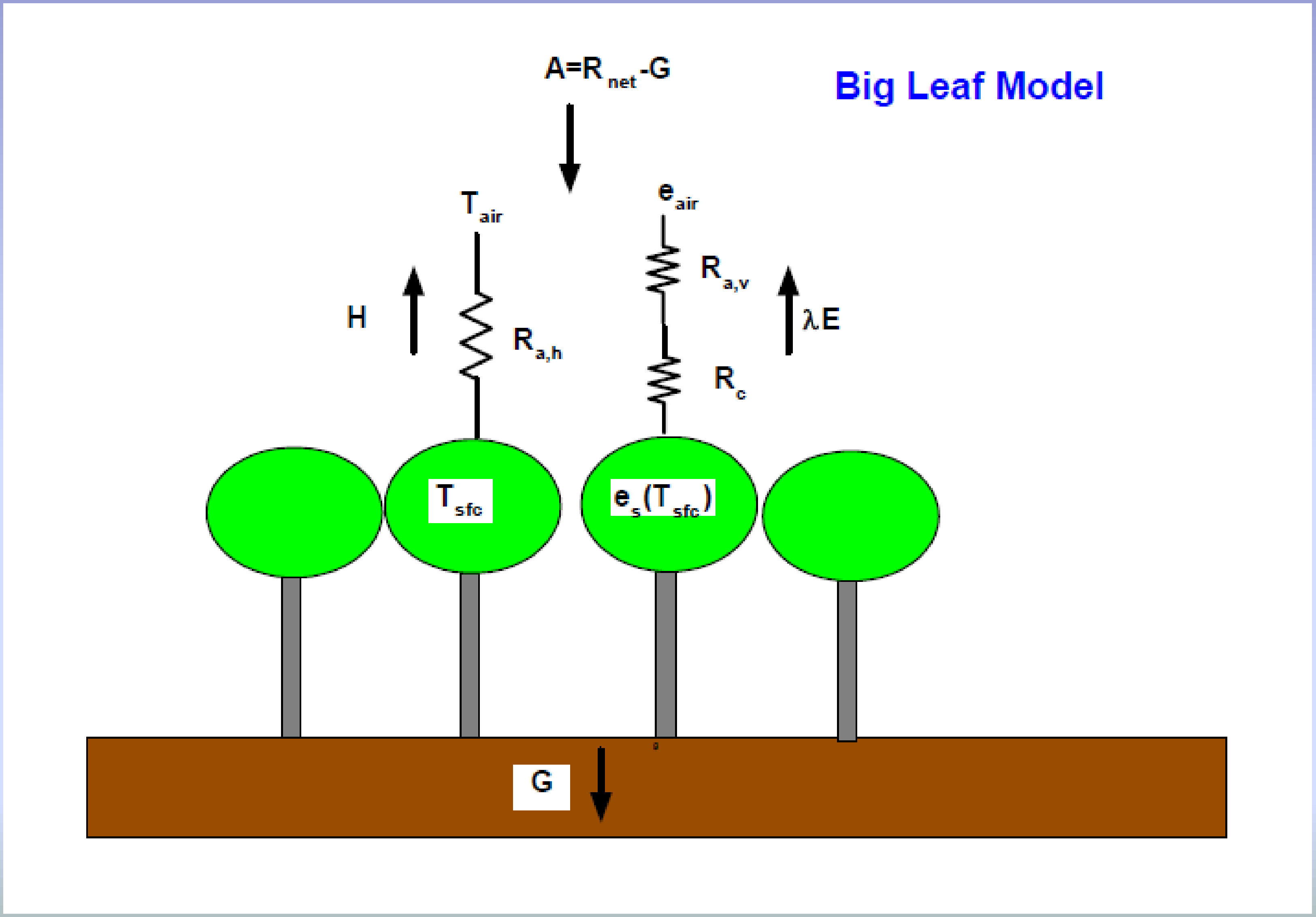
"First Generation" Biophysics (c. 1984)



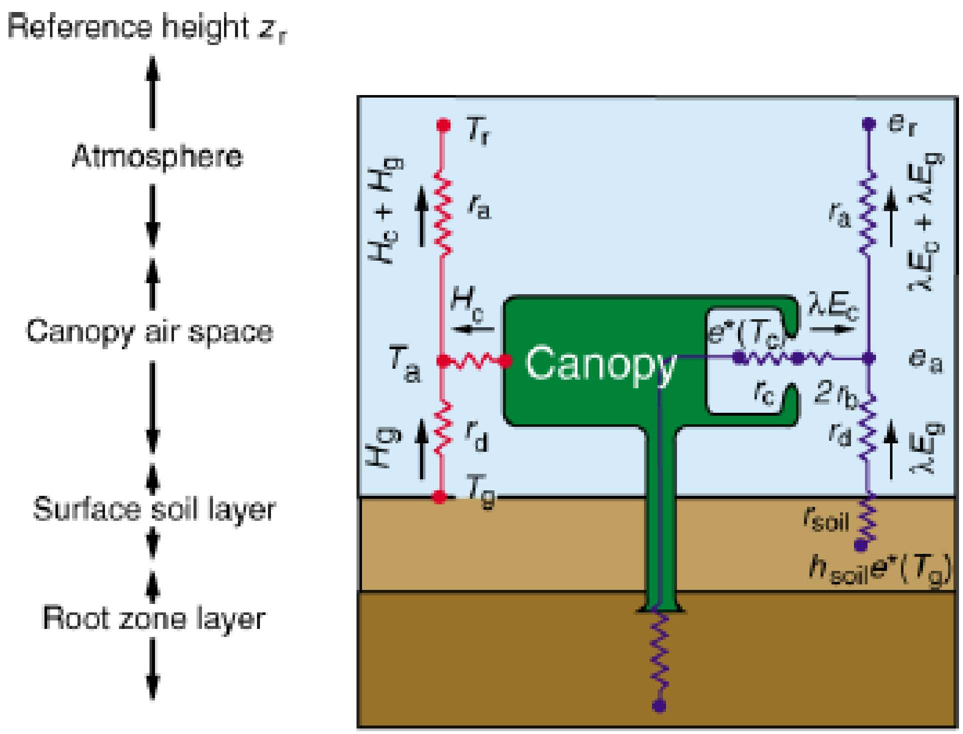


- Storage of water and heat in simple reservoirs
- Fill bucket with rain/snow
- Runoff when bucket is full
- Independent specification (maps) of surface properties like roughness and albedo

- Resistance is aerodynamic $1 / (C_d U)$
- Variable resistance for evaporation depends on soil moisture store

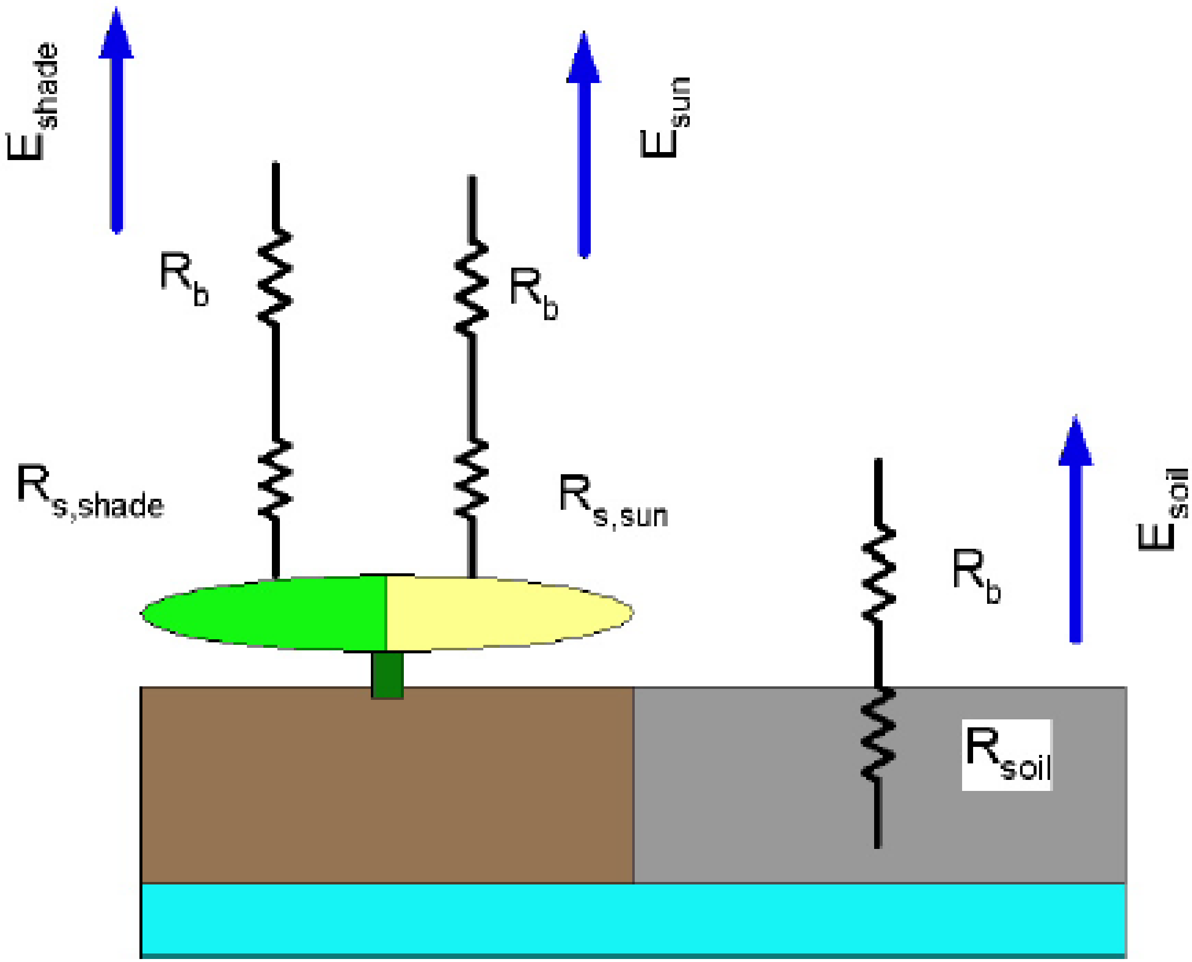

Big Leaf Model
A=R net -G
T air
e air
H
R a,h
R a,v
λE
R c
T sfc
e s (T sfc)
G

Second Generation Biophysics (c. 1990)

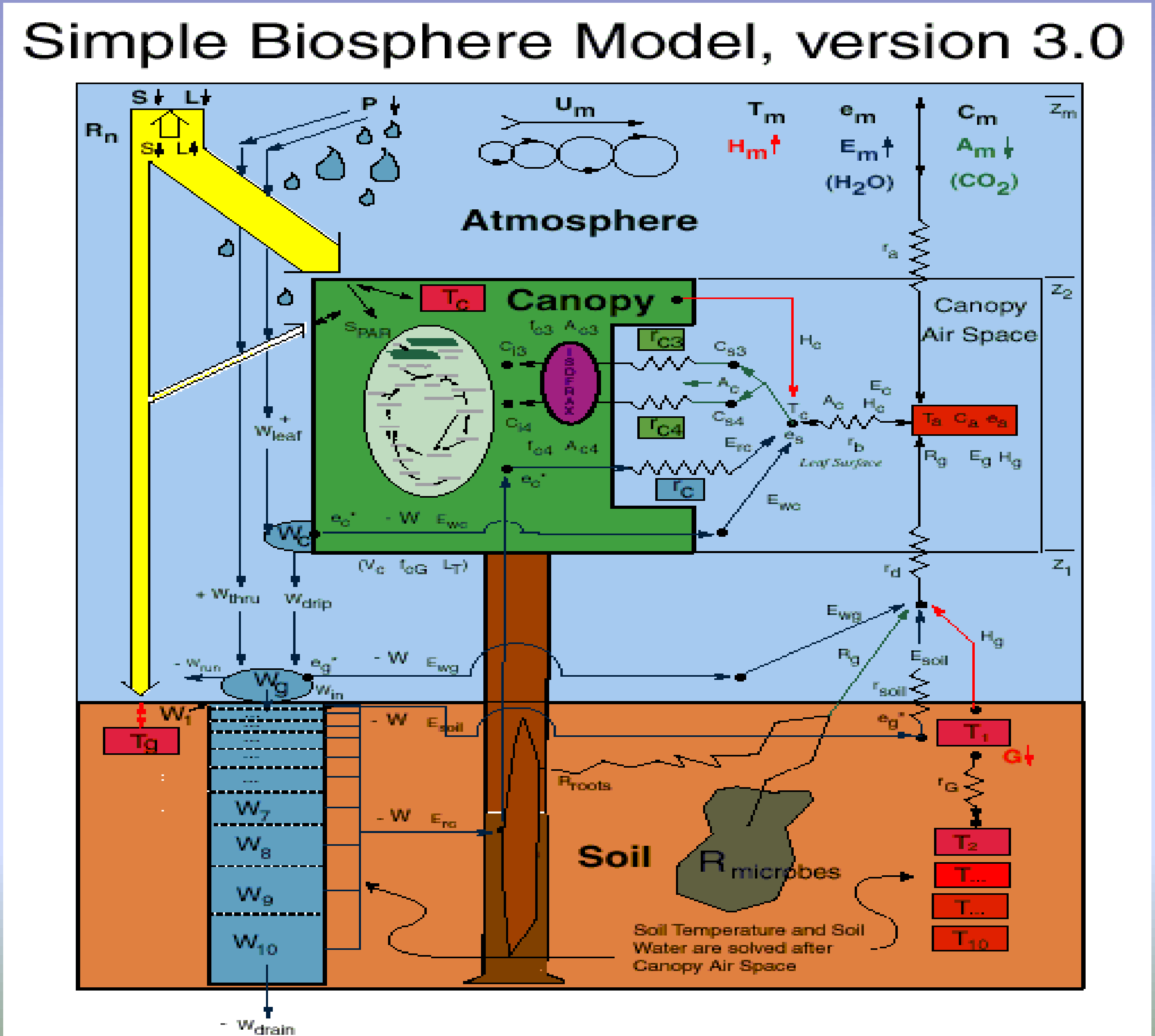


- e.g., BATS, SiB
- "Circuit" analogy (resistance network) for fluxes
- Biophysical consistency, with surface properties based on veg type

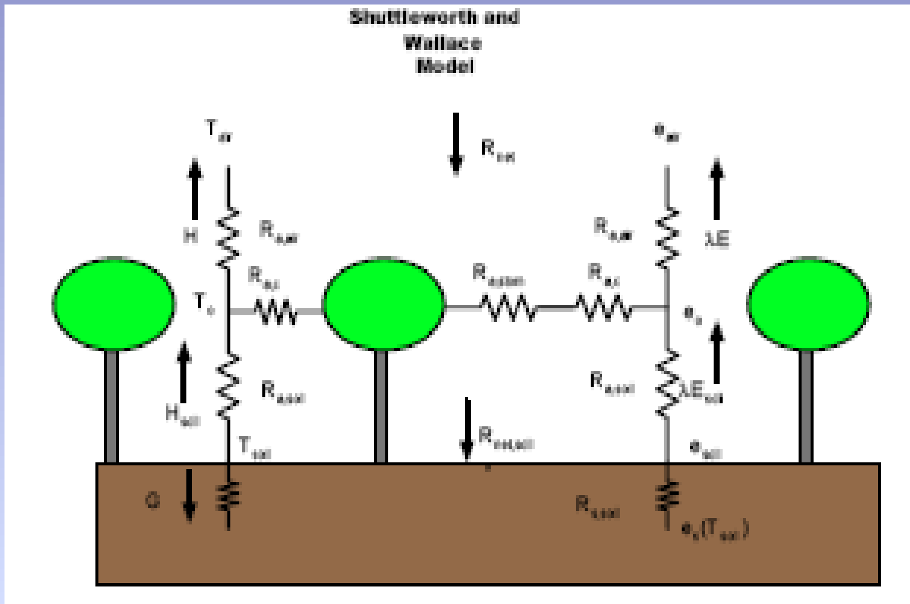
Dual Source:
Two Patch Model



Current approach (2009-2012)



Soil – vegetation coupling and tritium transfer



The Shuttleworth-Wallace model defines fluxes from the vegetative and soil components with a resistance network.
With the Shuttleworth-Wallace model, there is need to define values of the humidity deficit, temperature and vapour pressure at the canopy source height, D_0, T_0, e_0.

By analogy, for HTO:

$$F_c(R_{aa}+R_{ab}+R_{ac})+F_sR_a=C_a-C_c$$

$$F_cR_a+F_s(R_{aa}+R_{as}+R_{ss})=C_a-C_s$$

C_a – HTO concentration in air;
C_c – HTO concentration in vegetation;
C_s – HTO concentration in soil;
R_{aa} – atmospheric resistance between reference level and canopy source height;
R_{ac} – boundary layer resistance;
R_{sc} – canopy resistance;
R_{as} – atmospheric resistance between canopy source height and soil surface;
R_{ss} - soil resistance;
F_c - flux atmosphere – vegetation;
F_s - flux atmosphere – soil.

$$F_c=V_{ex}(C_a-C_{va})-V_{ex2}(C_a-C_{sa})$$

$$F_s=V_{ex1}(C_a-C_{sa})-V_{ex2}(C_a-C_{va})$$

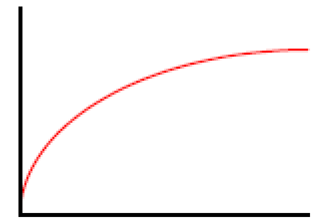
Details are given elsewhere
(A. Melintescu, D. Galeriu, “A versatile model for tritium transfer from atmosphere to plant and soil”, *Radioprotection*, Suppl. 1, Vol. 40 (2005), S437-S442, May 2005)

Examples: Non-Linear Biophysical Processes

Photosynthesis

$$A \sim \frac{aI}{b + cI};\frac{dC}{e + fC}$$

$$aA^3 + bA^2 + cA + d = 0$$



Transpiration

$$e_s(T) \sim \exp(T)$$

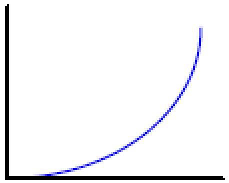
$$aLE^2 + bLE + c = 0$$

Respiration

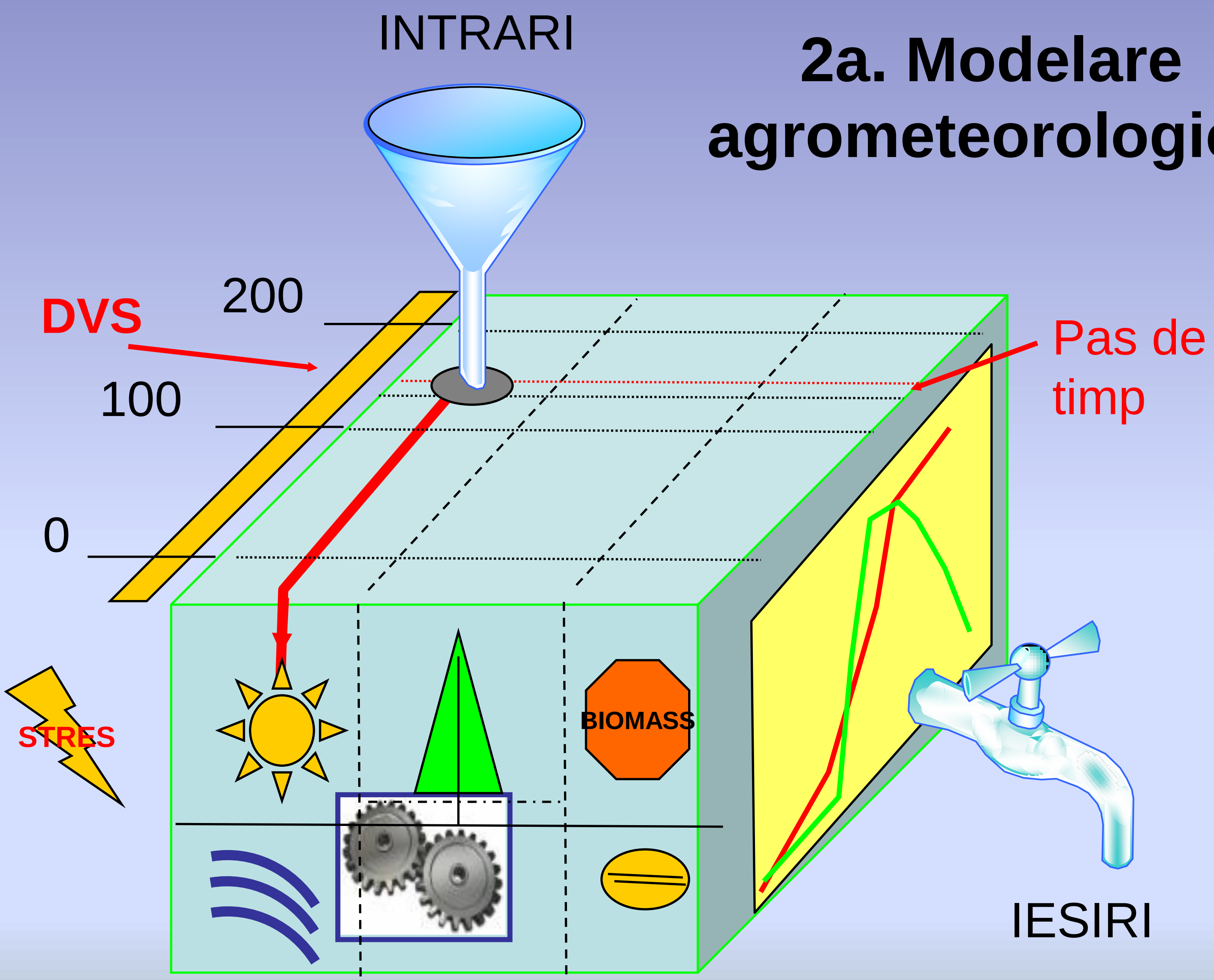
$$R_d \sim \exp(T)$$

Leaf Temperature

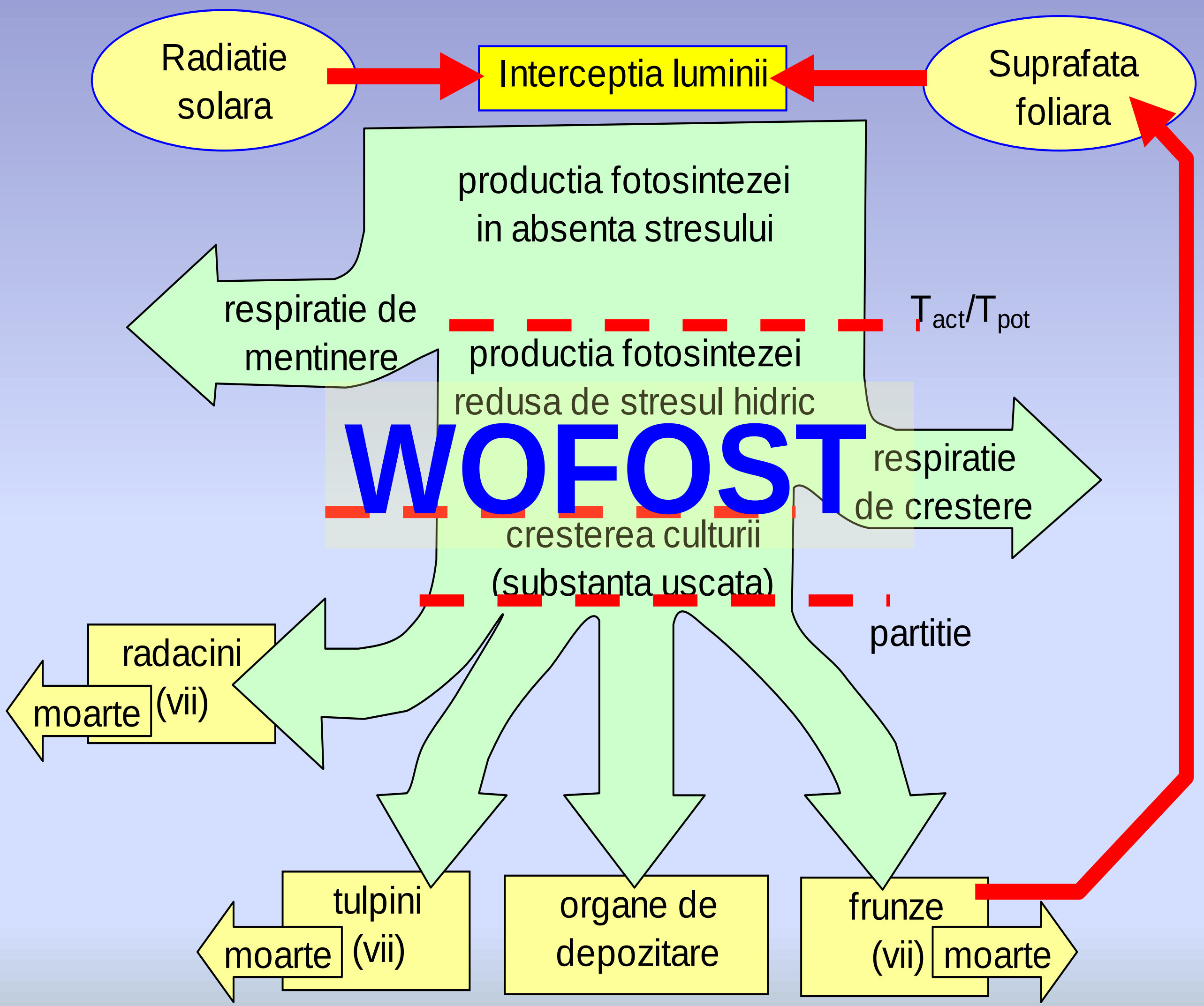
$$L\uparrow \sim T_s^4$$



2a. Modelare agrometeorologica

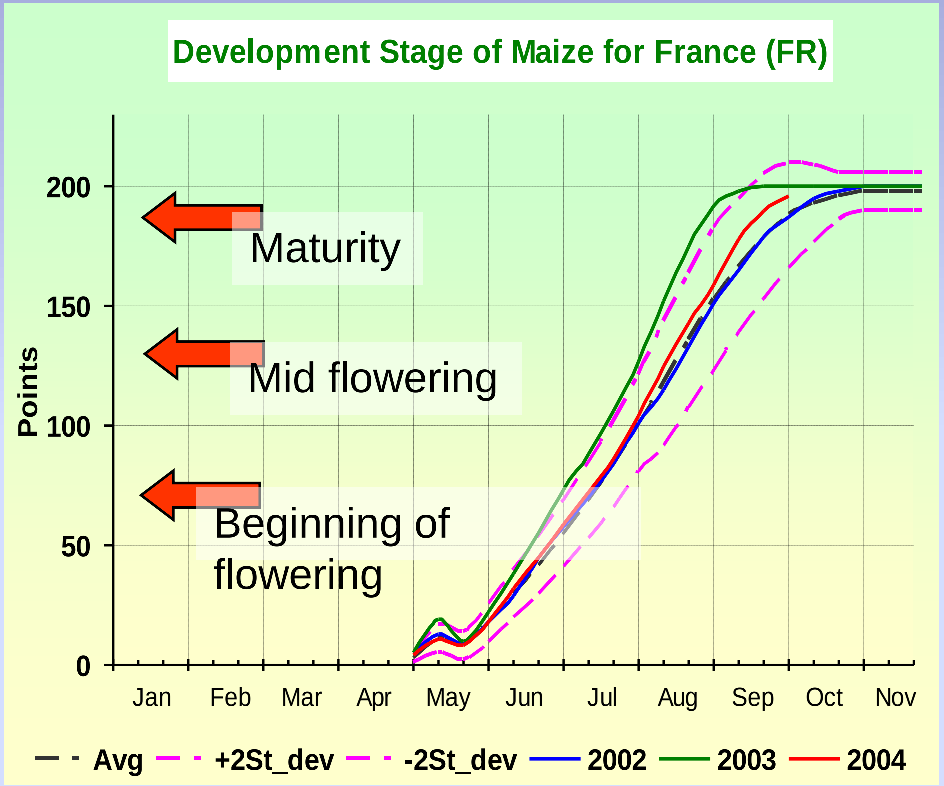


Structura WOFOST



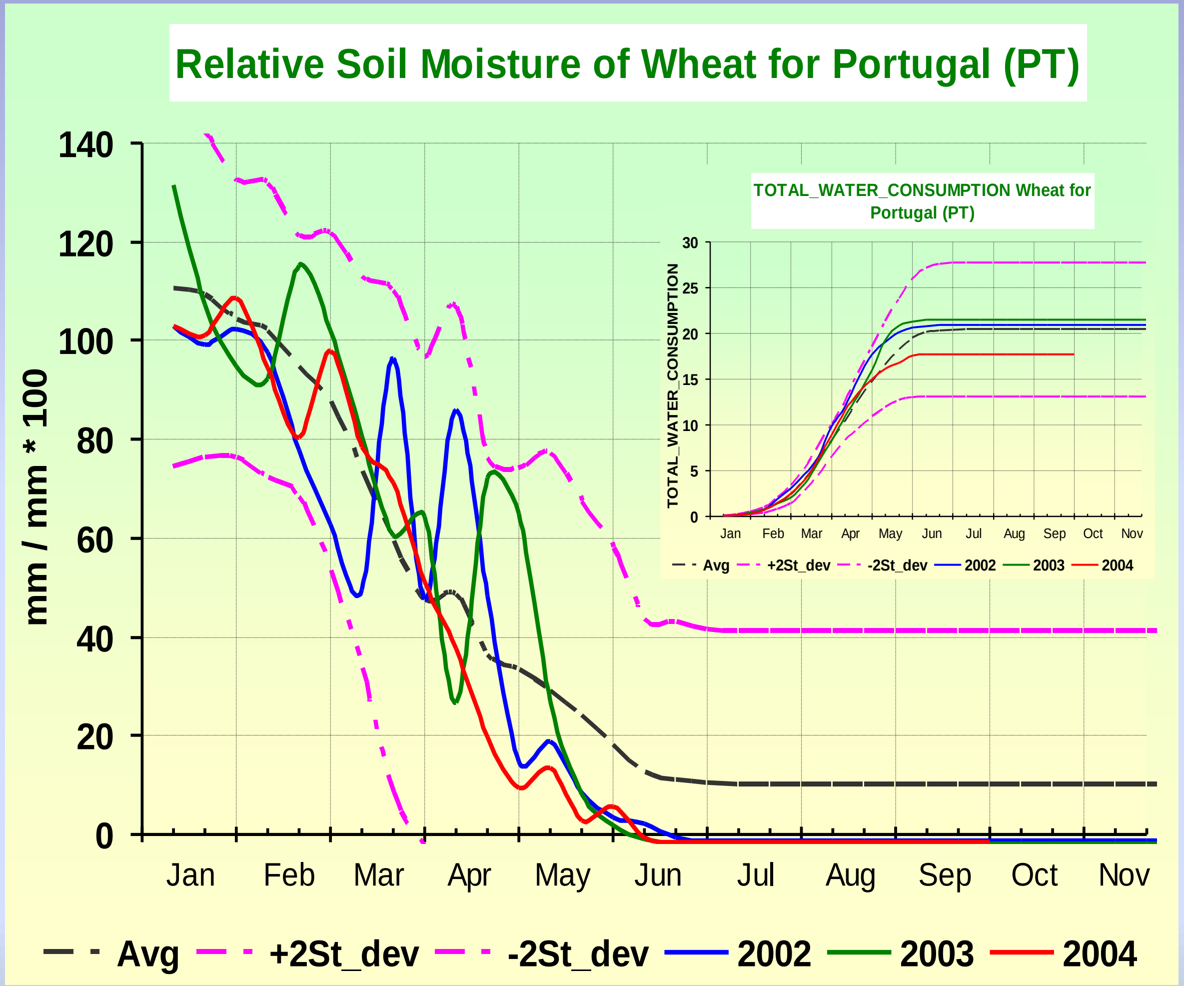
IESIRI

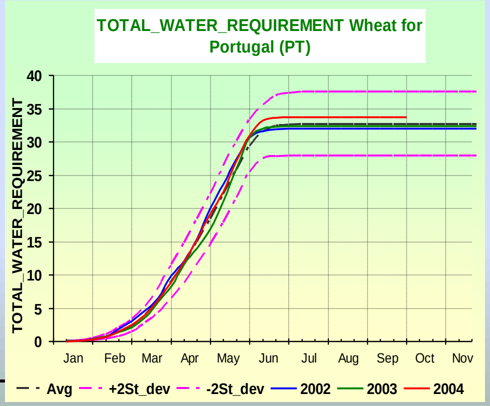
- **FENOLOGIE**
- Umiditate sol
- LAI
- BIOMASA



IESIRI

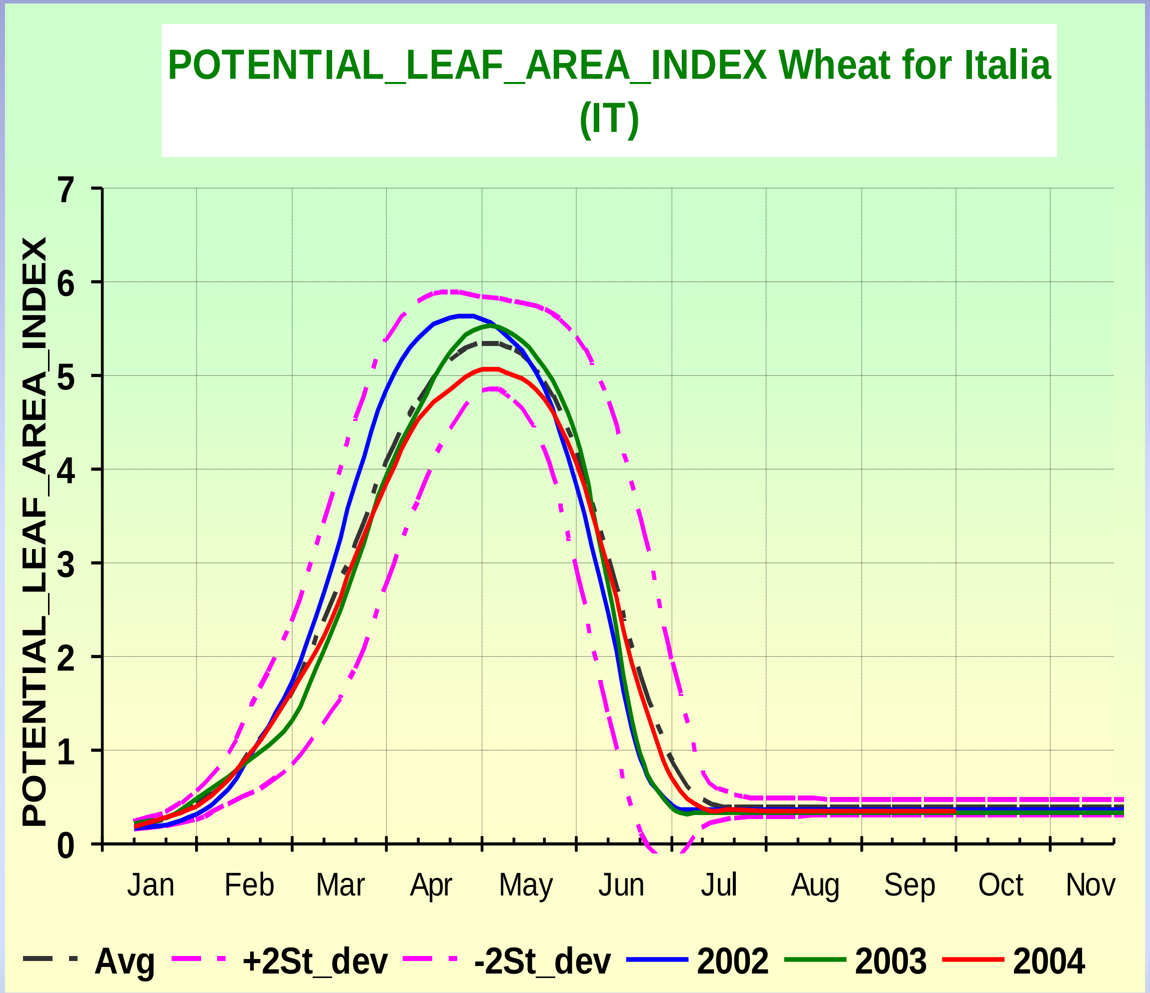
- FENOLOGIE
- **Umiditate sol**
- LAI
- BIOMASA

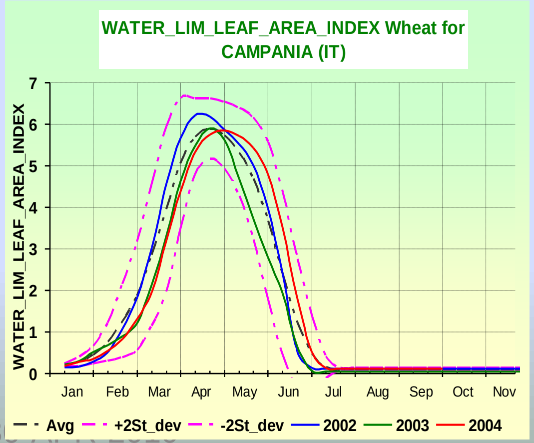




IESIRI

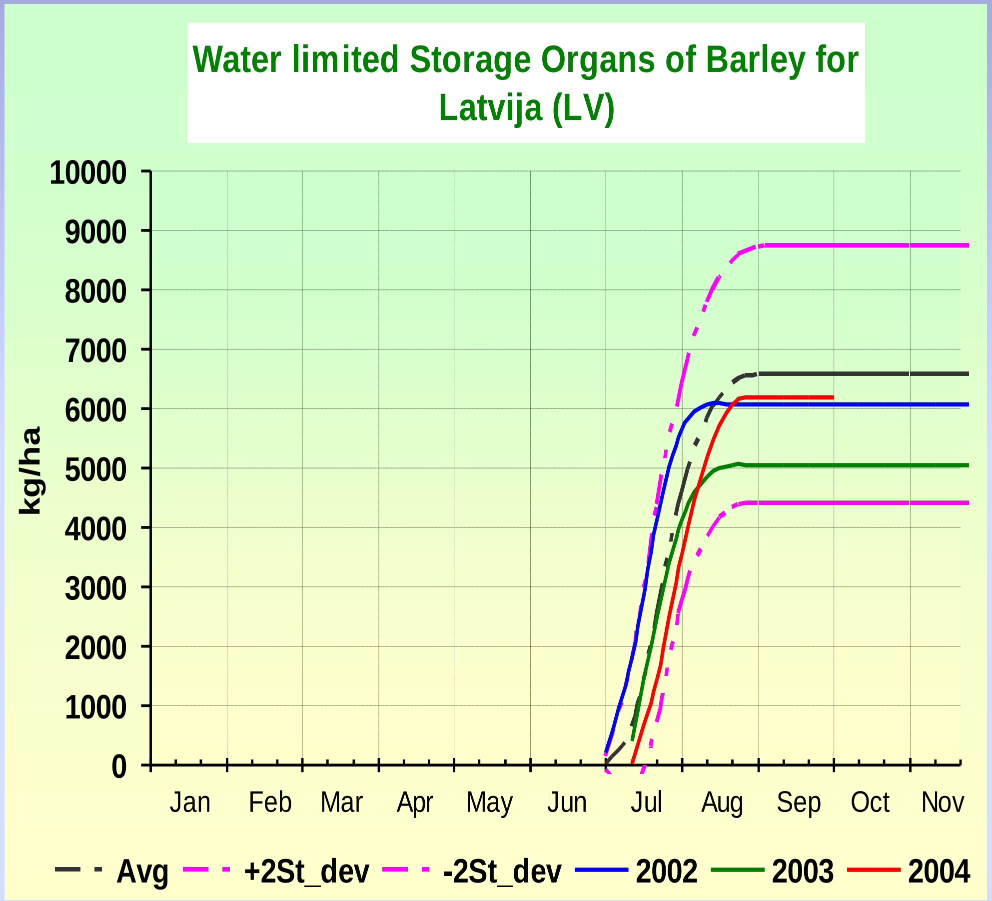
- PHENOLOGY
- SOIL MOISTURE
- **LAI**
- BIOMASS





IESIRI

- Fenologie
- Umiditate sol
- LAI
- **BIOMASA**
  - **Totala**
    - **Potentiala**
    - **Limitata de apa**
  - **Organe recoltabile**
    - **Potentiala**
    - **Limitata de apa**



Avantajele simulării (I)

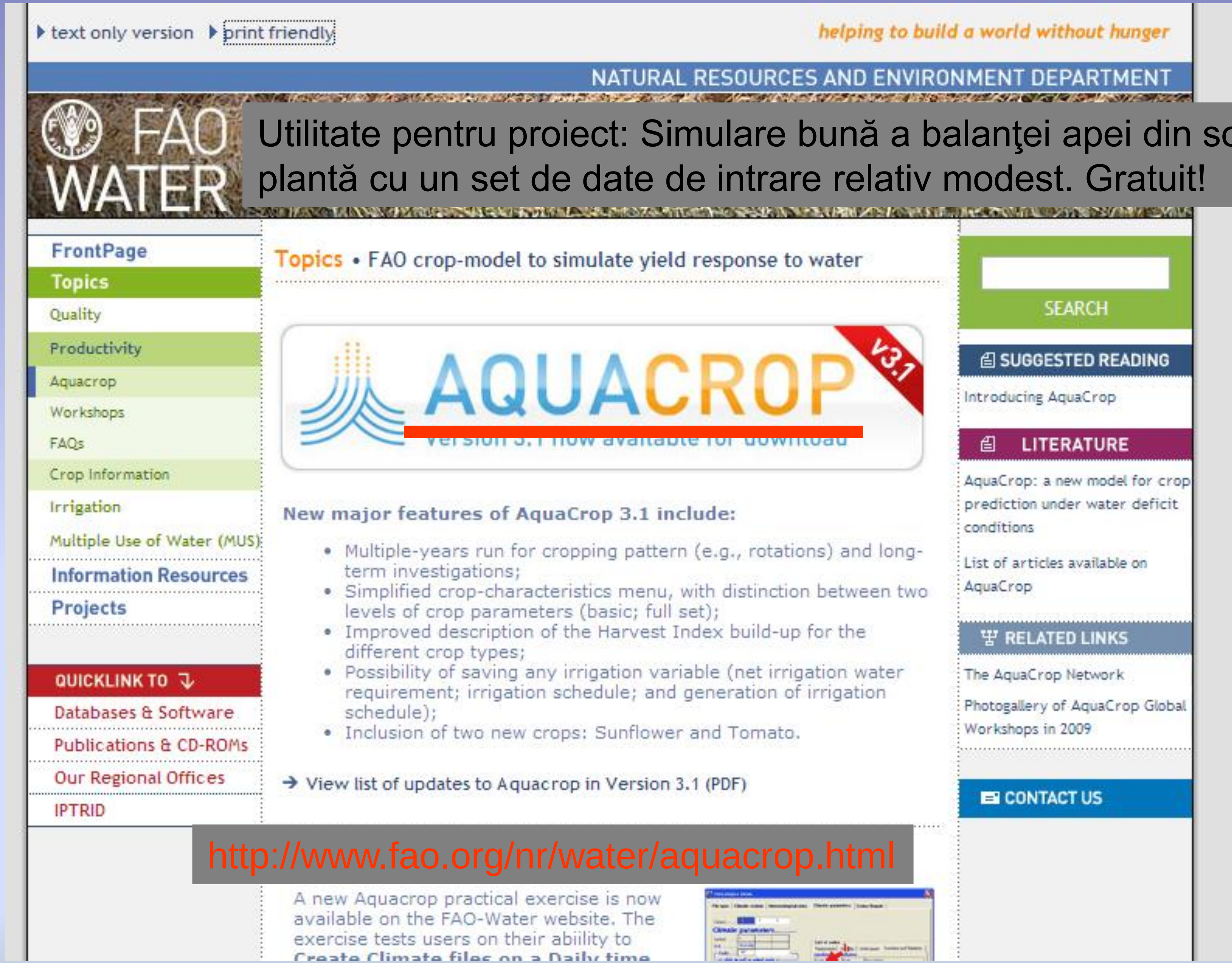
- se scot în evidenţă variabilele semnificative;
- pe lângă medii şi dispersiile unor distribuţii de valori, se obţin şi repartiţiile de frecvenţă, necesare pentru studiul spectral al datelor;
- o simulare poate fi oricând efectuată cu scopul de a verifica o soluţie nesigură obţinută pe cale analitică;

Avantajele simulării (II)

Singura metodă utilizabilă în cazul prognozei distribuţiei tritiului în plante.

- simularea este cel mai adesea mult mai ieftină decât alte forme de experimentare;
- simularea permite intuirea unor fenomene reale şi prin urmare are un caracter instructiv;
- în cele mai multe cazuri simularea permite controlul asupra timpului, prin care fenomene care pot dura foarte mult pot fi studiate în câteva minute.

Utilitate pentru proiect: Simulare bună a balanţei apei din sol şi plantă cu un set de date de intrare relativ modest. Gratuit!

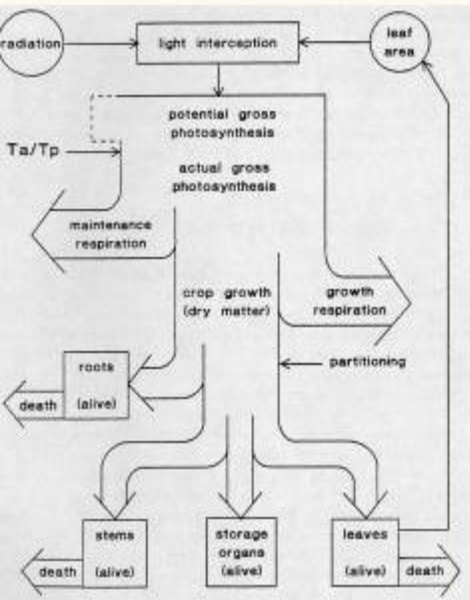


http://www.fao.org/nr/water/aquacrop.html

European Commission
Joint Research Centre
MARS

WOFOST

Utilitate pentru proiect: Surse disponibile. Model deja asimilat în IFIN HH. Varianta utilizată la JRC-ISPRA în CGMS este utilizată operaţional pentru prognozarea producţiilor agricole pentru întreagul continent.Gratuit!



A crop growth model developed by the DLO-Winand Staring Centre (SC-DLO) in conjunction with the Research Institute for Agrobiology and Soil Fertility (AB-DLO), both located in Wageningen, The Netherlands.

WOFOST is a quantitative deterministic model that can be used to simulate a number of crops, based on different sets of crop parameters. It takes account of certain soil characteristics and uses daily meteorological data for the calculation of evolution in time of the crop. WOFOST could be described as a 'point' model in the sense that it performs the calculations for one single point in space/time.

For an "UPDATED SYSTEM DESCRIPTION OF THE WOFOST CROP GROWTH SIMULATION MODEL AS IMPLEMENTED IN THE CROP GROWTH MONITORING SYSTEM APPLIED BY THE EUROPEAN COMMISSION" please go to http://www.supit.cistron.nl/ ← http://supit.net/main.php

JRC EUROPEAN COMMISSION

http://mars.jrc.it/mars/Projects/WOFOST

Joint Research Centre
MARS

pean Commission > JRC > IPSC > MARS Unit > About us > AGRI4CAST > Crop yield forecast > The Crop Growth Monitoring System (CGMS)

t us | Projects | Bulletins & Publications | News & Events | Web Tools

MARS Unit
I4CAST
ARS Bulletins for Europe
rop yield forecast
rop modelling
rop Area Estimates
limate change and risk assessment
ata distribution
oftware Tools
opulation density grid for EU
DSEC
CAP
Staff

The Crop Growth Monitoring System (CGMS)

CGMS (bazat pe WOFOST):
http://mars.jrc.it/mars/About-us/AGRI4CAST/Crop-yield-forecast/The-Crop-Growth-Monitoring-System-CGMS

The Crop Growth Monitoring System developed by MARS Project provides the European Commission (DG Agriculture) with objective, timely and quantitative yield forecasts at regional and national scale. CGMS monitors crops development in Europe, ... and crop parameters. This mechanistic ... combination with phenological developm... characteristic of CGMS lies in its spatiali... soilsand crops parameters, through ele... core of the system is based on 2 deter... prepare data and to produce results ma... are used to forecast quantitative crops ...

In summary, CGMS consists of three m...

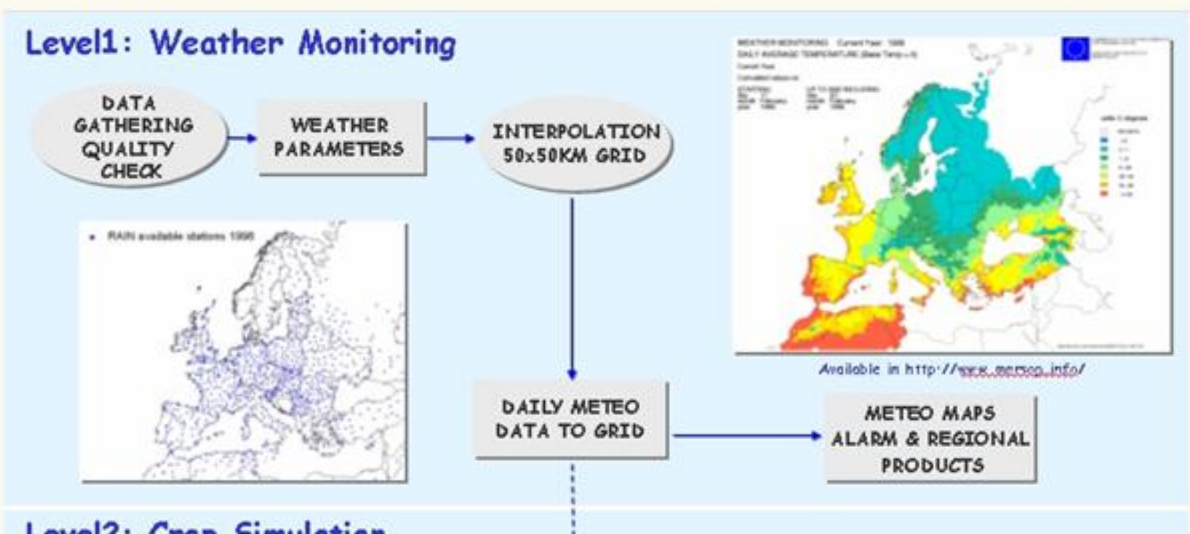
1. Interpolation of meterological dat...
2. Simulation of the crop growth
3. Statistical evaluation of the result...

(CGMS)

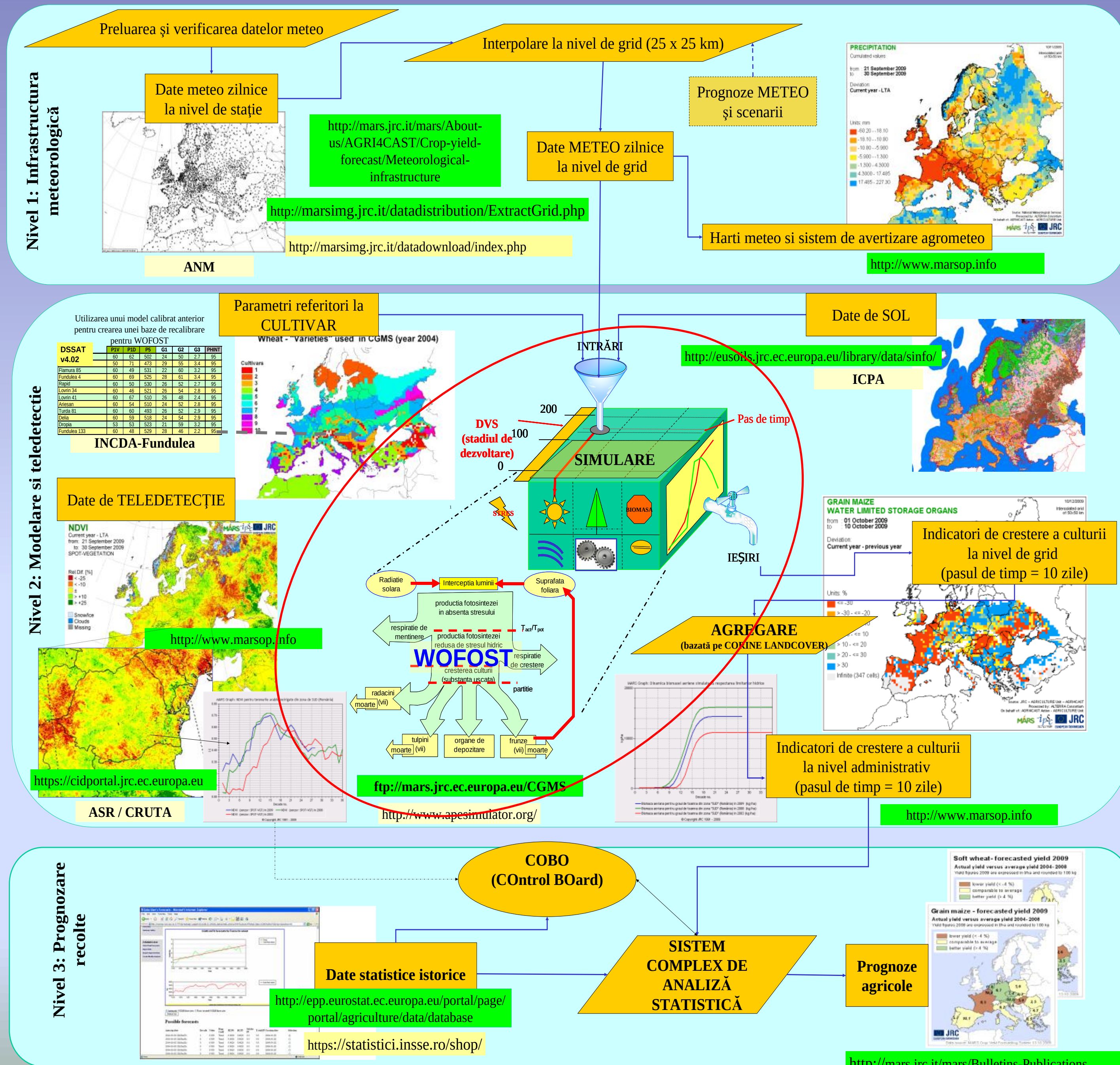
Latest CGMS package (version 9.2) is available here

From the public MARS ftp site ftp://mars.jrc.ec.europa.eu/CGMS/ you can download the latest CGMS package (version 9.2 documentation and software)

Figure 1.



CGMS JRC - ISPRA



Idei de adaptare CGMS pentru ROMANIA

Home page > Stics Model

Stics Model

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http://www.avignon.inra.fr/agroclim_stics_eng/modele_stics

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Person in charge of this software :

INRA - Agroclim - Groupe STICS
Site Agroparc - Domaine Saint Paul 84914 Avignon Cedex 9

Hereafter referred to as « the author »

This software is available on CD-ROM, useful in the environment Windows 95, 98 or NT o[...] compatible Personal Computer.

The conditions of use of this software are described below:

The PERSONAL license is the basic document which includes a software to install on 1 (one) hard disk drive and to use 1 (one) desktop.

It is specified that the word "desktop" means a configuration with 1 (one) screen and 1 (one) keyboard.

Utilitate pentru proiect: Parametrizare externalizată (uşor de adaptat). Admite în varianta STICS-Feuille forţarea LAI (posibilitate de utilizare ulterioară a datelor de teledetecţie). Comunitate de utilizatori – dezvoltatori bine dezvoltată. Testat pe scară largă. Gratuit!

SIRIUS wheat simulation model

Sirius

M.A. Semenov
Rothamsted Research
United Kingdom

P.D. Jamieson
Crop & Food Research
New Zealand

Sirius

Download

Sirius is a wheat simulation model that calculates biomass from intercepted photosynthetically active radiation (PAR) and grain growth from simple partitioning rules. Leaf area index (LAI) is developed from a simple thermal time sub-model. Phenological development is calculated from the mainstem leaf appearance rate and final leaf number, with the latter determined by responses to daylength and vernalisation. Effects of water and N deficits are calculated through their influences on LAI development and radiation-use efficiency. Sirius has been calibrated for several modern wheat cultivars and was able to simulate crop growth accurately in a wide range of conditions, including Europe, NZ/Australia and USA and under climate change

Utilitate pentru proiect: Modelarea calităţii bobului. Eventual utilizabil pentru grâul de toamnă.

References:

- Jamieson PD, Semenov MA, Brooking IR & Francis GS (1998) Sirius: a mechanistic model of wheat response to environmental variation. Europ J Agronomy, 8:161-179 (pdf)
- Jamieson PD, Brooking IR, Semenov MA & Porter JR (1998) Making sense of wheat development: mechanisms of response to daylength and temperature Field Crops Research,55:117-127 (pdf)
- Jamieson PD & Semenov MA (2000) Modelling nitrogen uptake and redistribution in wheat. Field Crops Research, 68:21-29 (pdf)
- Brooks RJ, Semenov MA & Jamieson PD (2000) Simplifying Sirius: sensitivity analysis and development of a meta-model for yield prediction Europ J Agronomy, 14:43-60 (pdf)
- Lawless C, Semenov MA & Jamieson PD (2005) A wheat canopy model linking leaf area and phenology Europ J Agronomy, 22:19-32 (pdf)
- Semenov MA ,Jamieson PD & Martre P (2007) Deconvoluting nitrogen use efficiency in wheat: a simulation study, Europ. J Agronomy, 26:283-294 (pdf)
- Semenov MA, Martre P & Jamieson PD (2009) Quantifying effects of simple wheat traits on yield in water-limited environments using modelling approach. Agric.Forest Meteorology, 149:1095–1104 (pdf)

http://www.rothamsted.bbsrc.ac.uk/mas-models/sirius.php http://www.icasa.net/dssat/

Introduction

The Decision Support System for Agrotechnology Transfer (DSSAT) is a software package integrating the effects of soil, crop phenotype, weather and management options that allows users to ask "what if" questions and simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. It has been in use for more than 15 years by researchers in over 100 countries.

DSSAT is a microcomputer software product that combines crop, soil and weather data bases into standard formats for access by crop models and application programs. The user can then simulate multi-year outcomes of crop management strategies for different crops at any location in the world.

DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results. Crop model validation is accomplished by inputting the user's minimum data, running the model, and comparing outputs. By simulating probable outcomes of crop management strategies, DSSAT offers users information with which to rapidly appraise new crops, products, and practices for adoption.

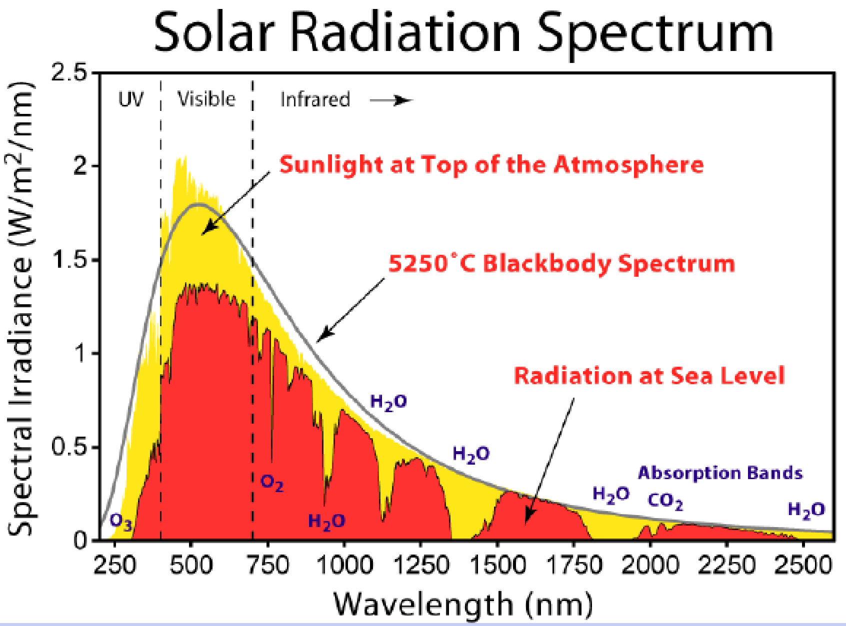
ALSO
SWAP better soil
GECROSS better nitrogen and sun-shade leaf temperature
include Farquhar model last variant

For solute in soil-plant

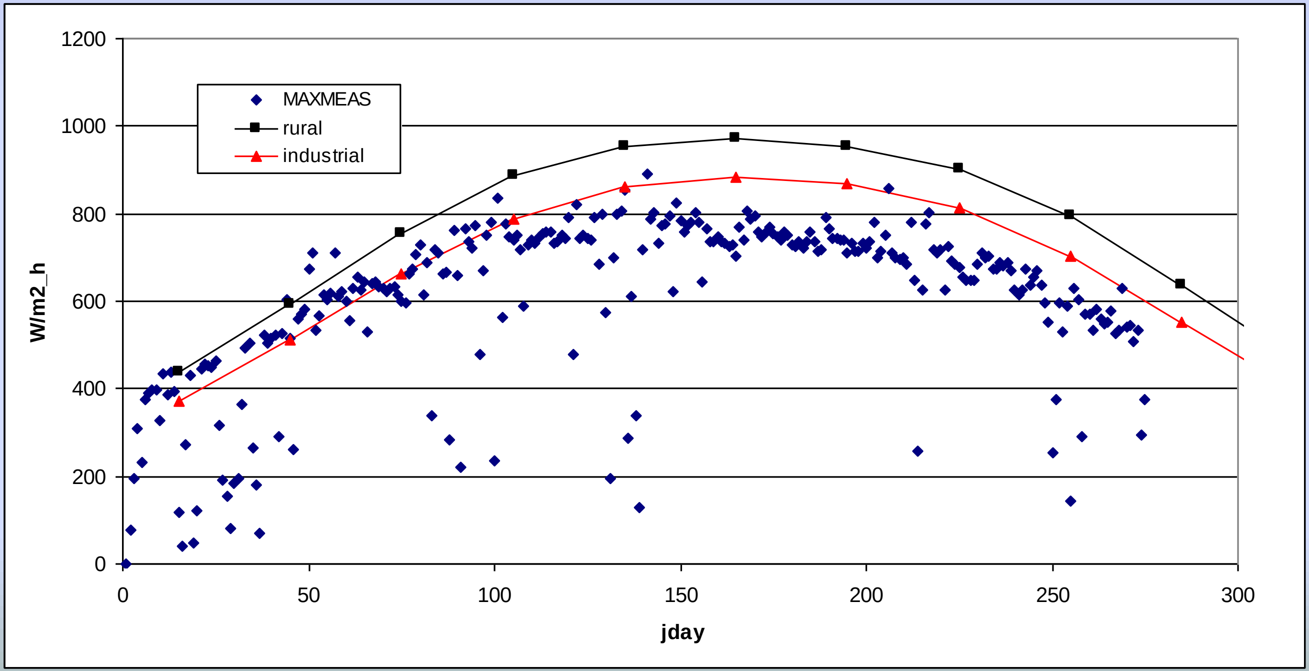
Campbell
CHEMFLO
HYDRUS1D

For Tritium
STUPITRI (1992 DG)
TRICAERB (1994 DG)
FDMH (2000 DG)
FDMH+ (2005 DG AM)

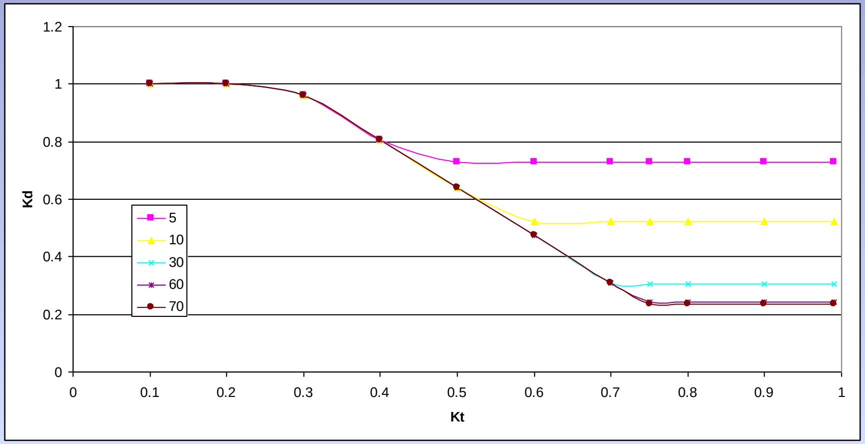
QUIZ the simpler complex model to be used



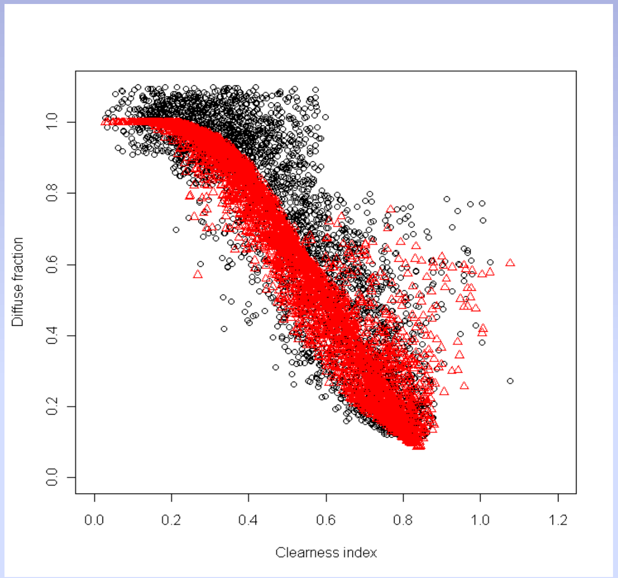
Clear sky model and solar radiation measured at IFIN-HH 2012
Construction works
Polluted the air
More than industrial!



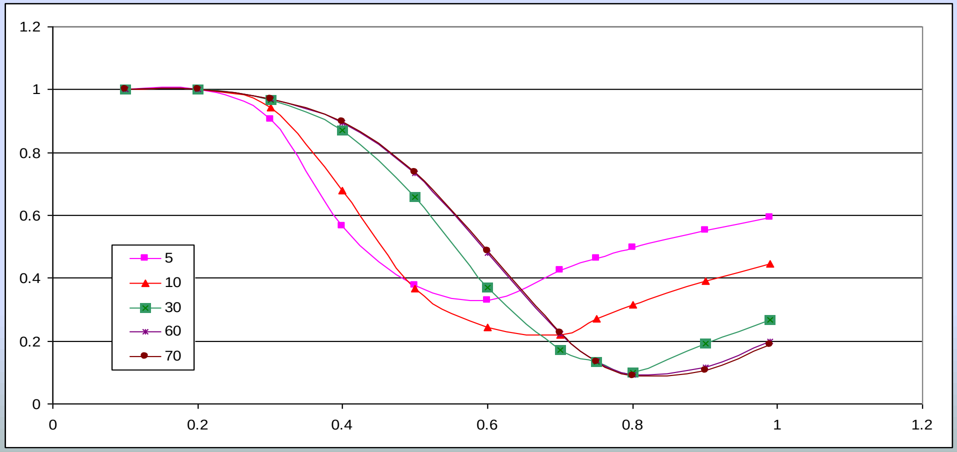
Diffuse fraction and atmospheric transmisivity



Old model - cf Spitters

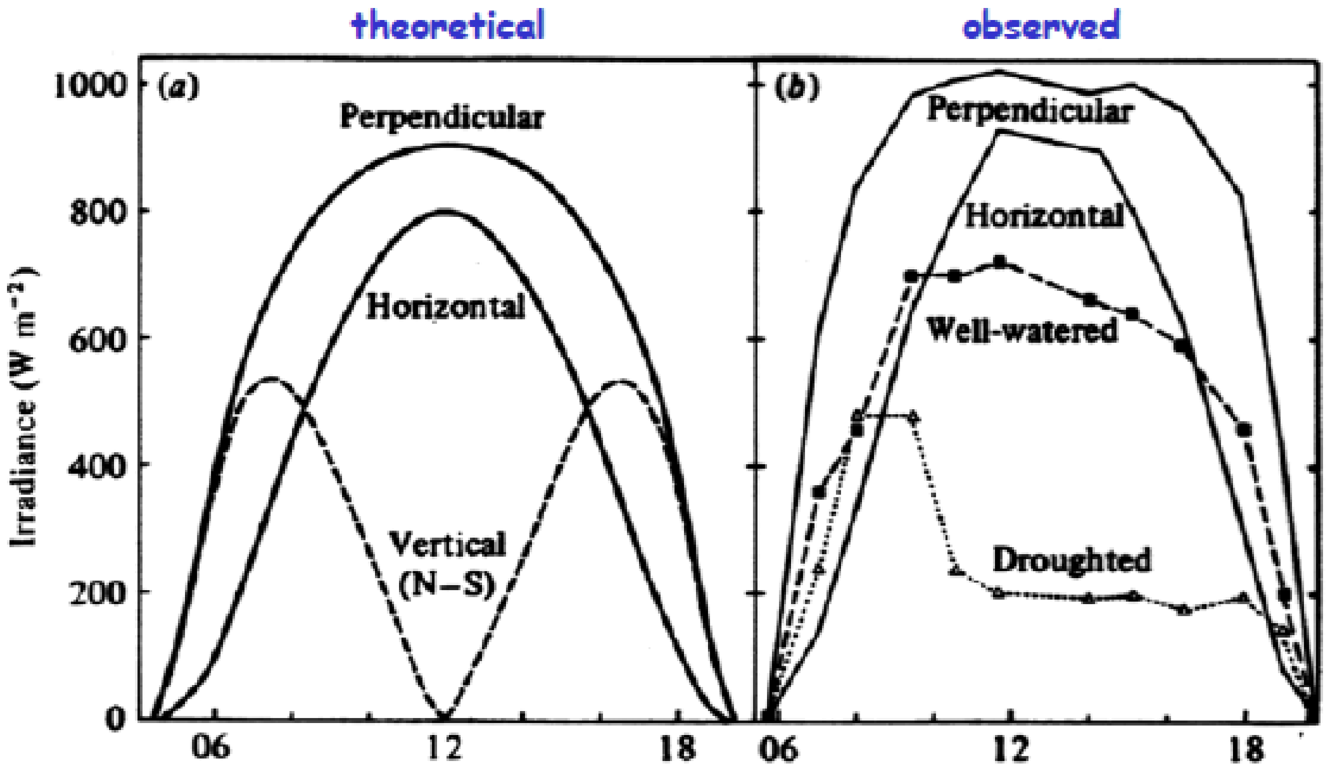


Experimental data (black)
Model (red)



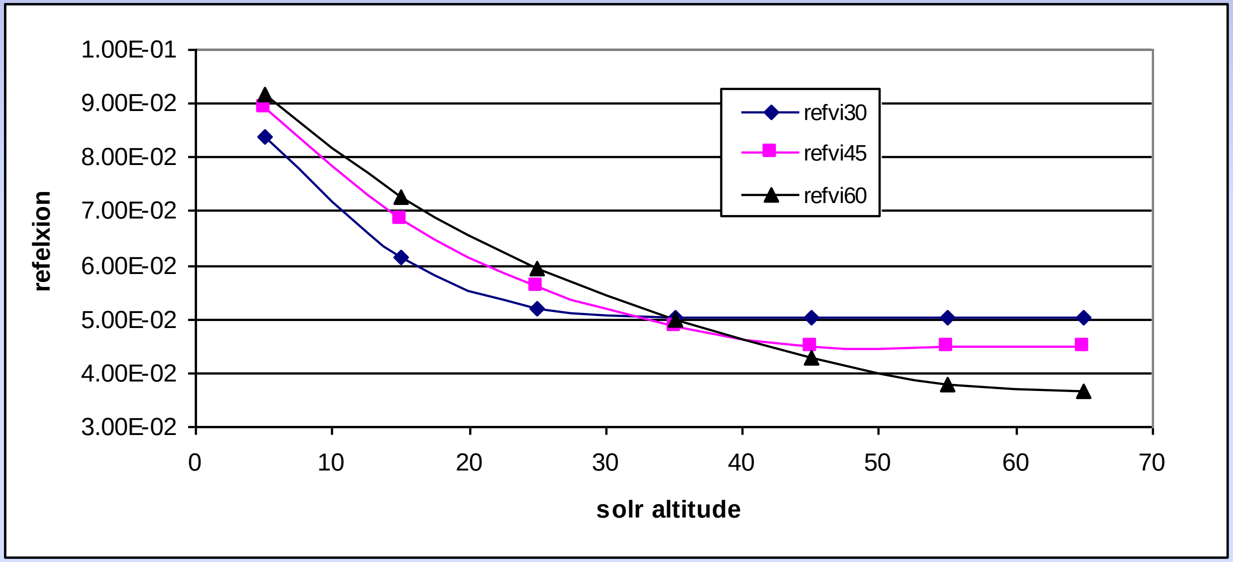
New model - our review

Dependence on Leaf Orientation



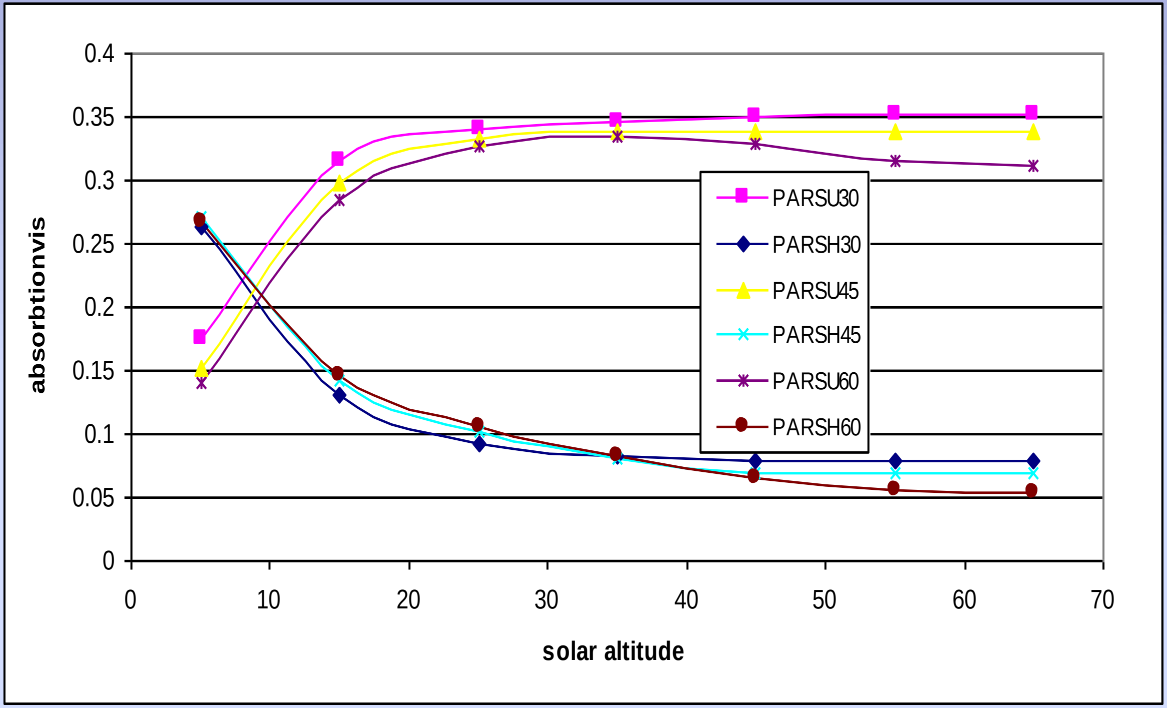
Incident radiation on leaf surfaces depends on diurnally varying solar zenith angle and leaf orientation

Reflexion of visible solar light by plants with different leaf angle orientation



Comment: new genotype and old Romanian models are not very different

Absorption of visible light by sunny or shaded leafs of plants with different leaf angle



New and old genotype do not differ to much
Sunny and shaded leaves must be treated separately

Sunlit/Shaded Radiation Scheme

Sunlit LAI

Shaded LAI

$$L_{sun} = \int_0^{L_T} f_{sun}(L)\,dL = \left[1 - \exp\left(-k_b L_T\right)\right] / k_b \qquad L_{shaded} = L_T - L_{sun}$$

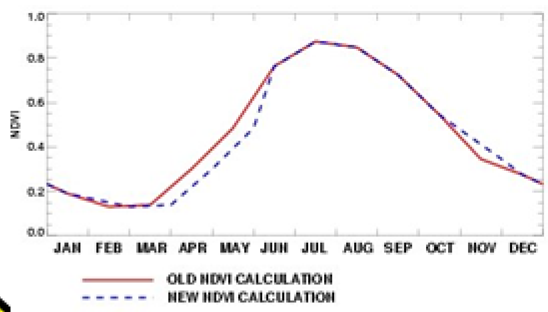
Radiation absorbed by sunlit leaves:

$$I_{sun} = \int_0^{L_T} I_{beam}(L)\, f_{sun}(L)\,dL + \int_0^{L_T} I_{diffuse}(L)\, f_{sun}(L)\,dL + \int_0^{L_T} I_{scattered\_beam}(L)\, f_{sun}(L)\,dL$$

Radiation absorbed by Shaded leaves:

$$I_{shaded} = \int_0^{L_T} I_{diffuse}(L)\left[1 - f_{sun}(L)\right]dL + \int_0^{L_T} I_{scattered\_beam}(L)\left[1 - f_{sun}(L)\right]dL$$

NDVI Interpolation



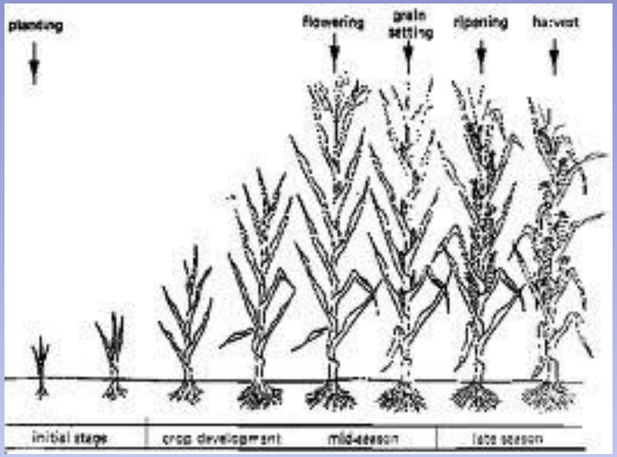
Monthly NDVI values are used to obtain time-varying vegetation parameters such as:

- Leaf Area Index (LAI)
- Fraction of absorbed PAR (fPAR)
- Green fraction
- Roughness length

<u>OLD SCHEME</u>: Monthly maximum NDVI is assigned to the midpoint of each month

<u>NEW SCHEME</u>: Slope are curvature of annual NDVI cycle is examined, and assignment of observation date follows these rules:

- Slope>0, curvature>0; end of month
- Slope<0, curvature>0; beginning of month
- Otherwise; midmonth



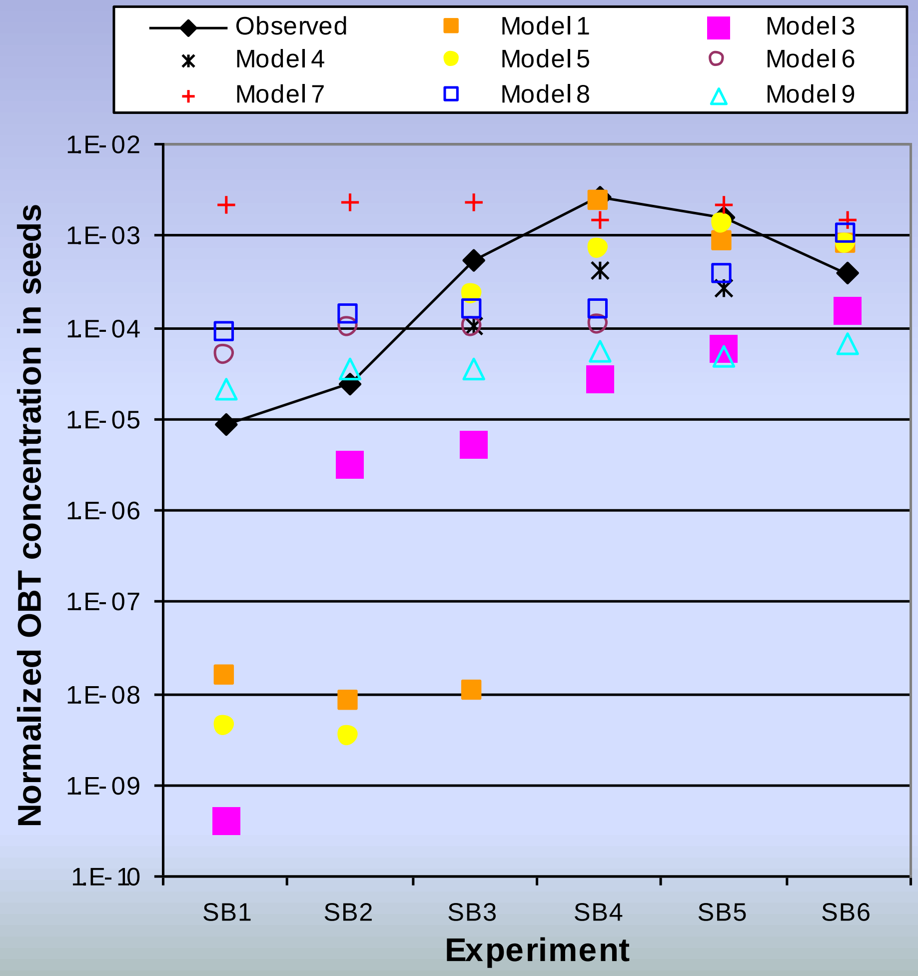
CROP DEVELOPMENT STAGE
0 emergence
1 flowering'2 maturity-harvest

Depends on Growing degree days

	RF	FM
F376	650	890
OLT	655	880
F475M	615	870
Crisana	700	890
Campion	645	875
Rapsodia	680	830
CV	0.12	0.07

NOT ONLY TEMPERATURE

OBT in boabe de soia
Experiment si modelare (2006 IAEA)



Open problems in OBT modelling in crops

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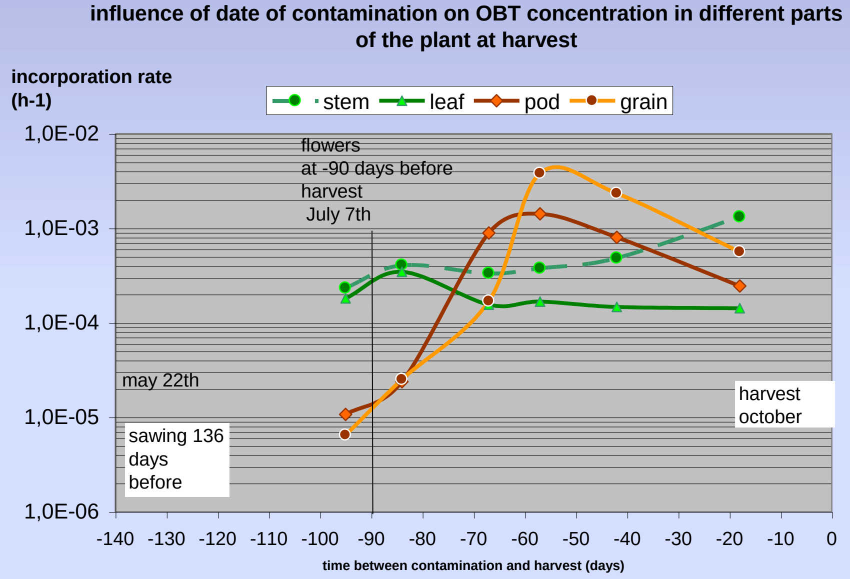
1st Workshop on OBT (Organically Bound Tritium) and its Analysis
Balaruc les Bains, France, 21 – 24 May 2012

Second open problem – What type of photosynthesis model? How simple / complex?

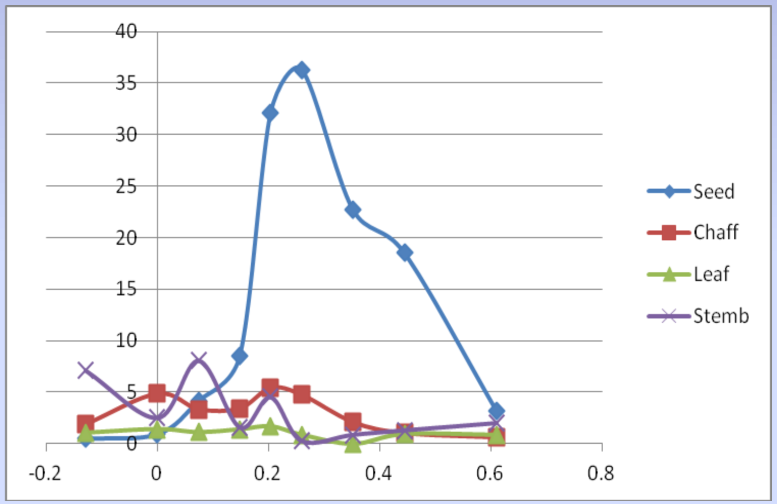
- Very complex models need too many specific parameters
- Very simple models ignore the role of nitrogen distribution in canopy, sun shaded leaves, and air-crop temperature difference
- A compromise between complex and simple approaches must be done together with tests with experimental data for HTO and OBT predictions at harvest
- The biochemical models with detailed consideration of biochemical sub-processes and one more parameter fitted, do not offer significant advantages over the simpler leaf models for explaining the field data.

Third open problem – Distribution of OBT in plants

Distribution of OBT in soybean plant parts



Distribution of OBT in rice plant parts at harvest at different exposures



Need to know partition fractions of the new formed dry matter

↓

Plant physiology and crop growth

Fifth open problem – OBT formation during the night

- Experiments clearly demonstrate the OBT production at night
- Comparable TLI for day and night
- TLI = (percentage of the OBT concentration in grain at harvest (Bq mL^{-1} water of combustion) /(TWT concentration in leaves (Bq mL^{-1}) at the end of exposure to HTO)
- Tangerine - TLI - 0.08–0.28% (day)
  - 0.21–0.71% (night) with the maximum in the middle of the ripening period
- Depends on the development stage
- In photosynthesis → soluble sugars and insoluble starch produced
- Starch - accumulated in leaves during the day time and night → starch is transformed (hydrolysed) in soluble sugars → consequently used in plant metabolism
- Starch hydrolysis in the presence of HTO is not enough to explain the OBT formation in night.

Fifth open problem – OBT formation during the night

- Many biochemical processes are common for both growth and maintenance respiration and among them the protein turnover can contribute to OBT production
- The share between starch and soluble sugar production in the day varies between crops and genotypes.
- The minimum amount of starch production must be enough for the plant maintenance in night conditions
- Crops and genotypes with higher starch production than the minimum amount are supposed to have a higher OBT production in night

Soils, water and roots

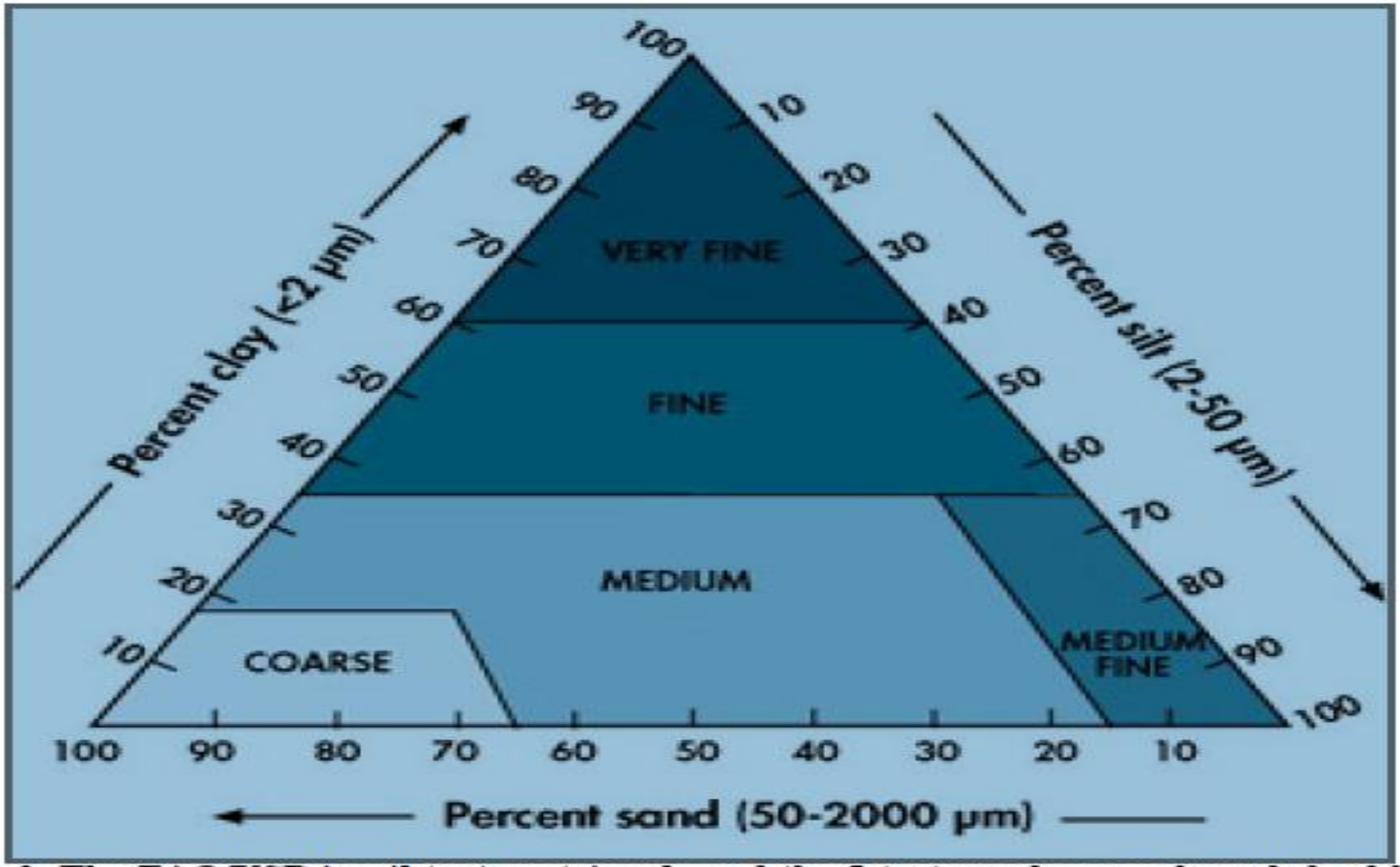


Figure 3. The FAO/USDA soil texture triangle and the 5 texture classes acknowledged by the 1:1,000,000 scale Soil Geographical Database and Soil Map of Europe.

At saturation, no air in soil- no growth; at drought- no growth, no root uptake

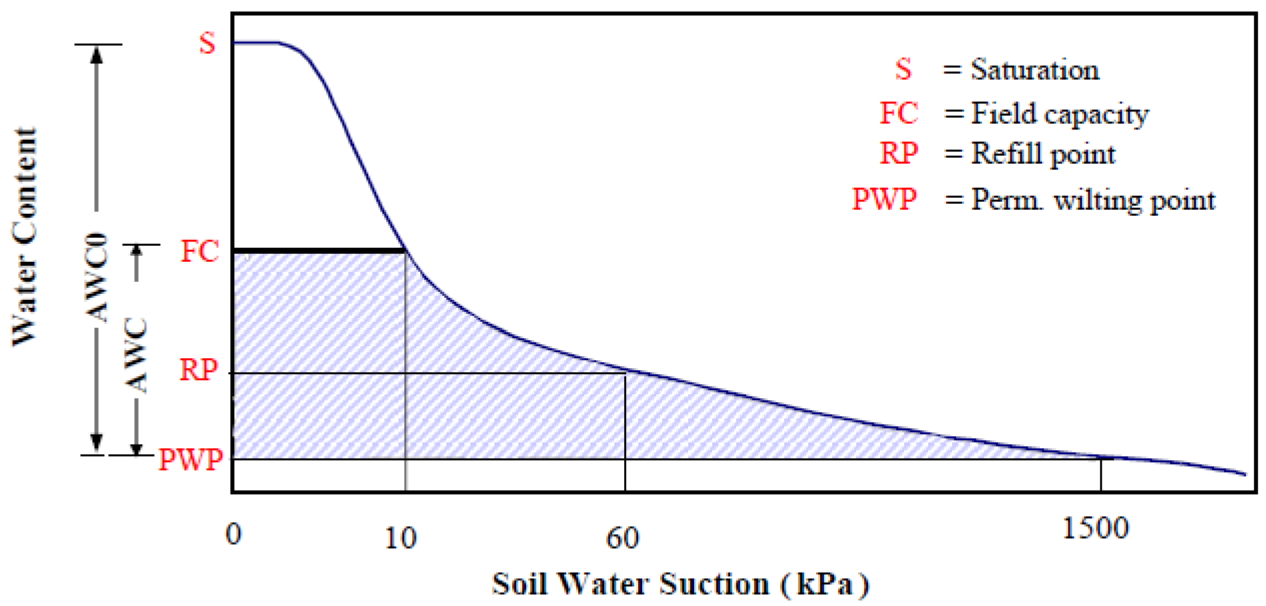
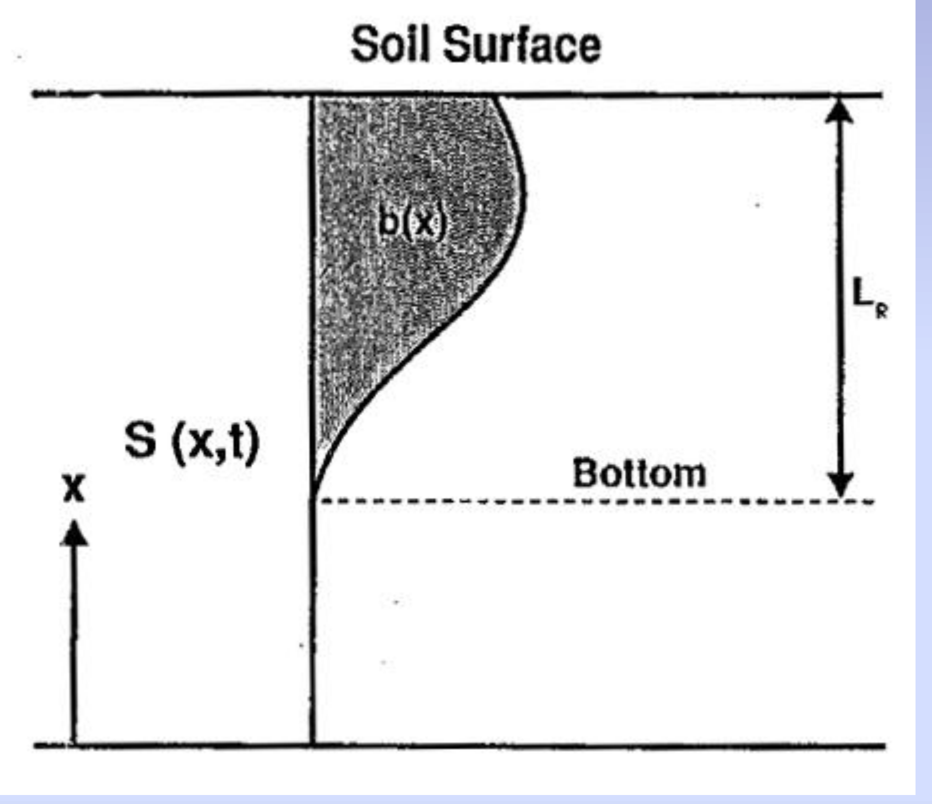
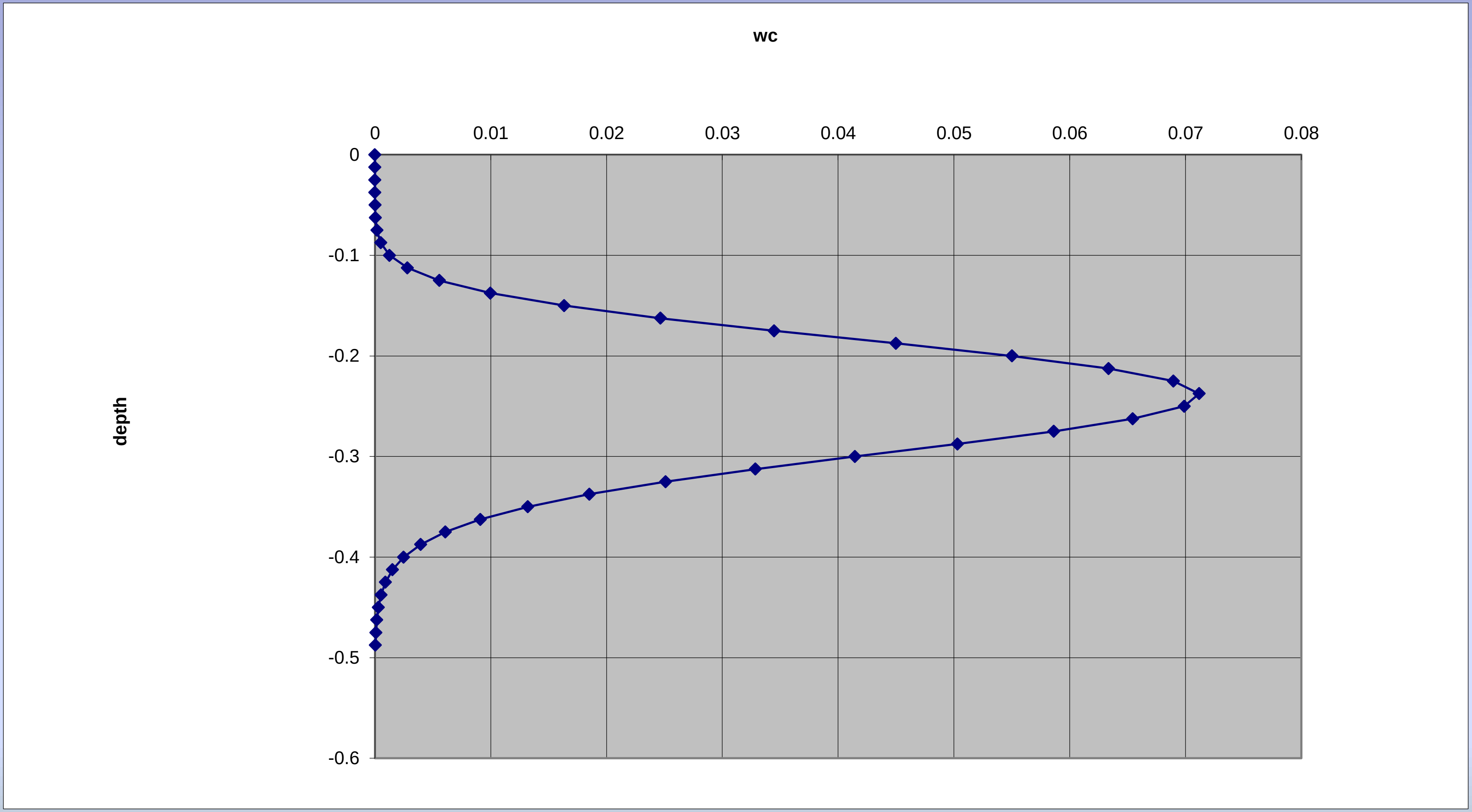


Figure 2.1 Typical Soil Water Characteristics Curve

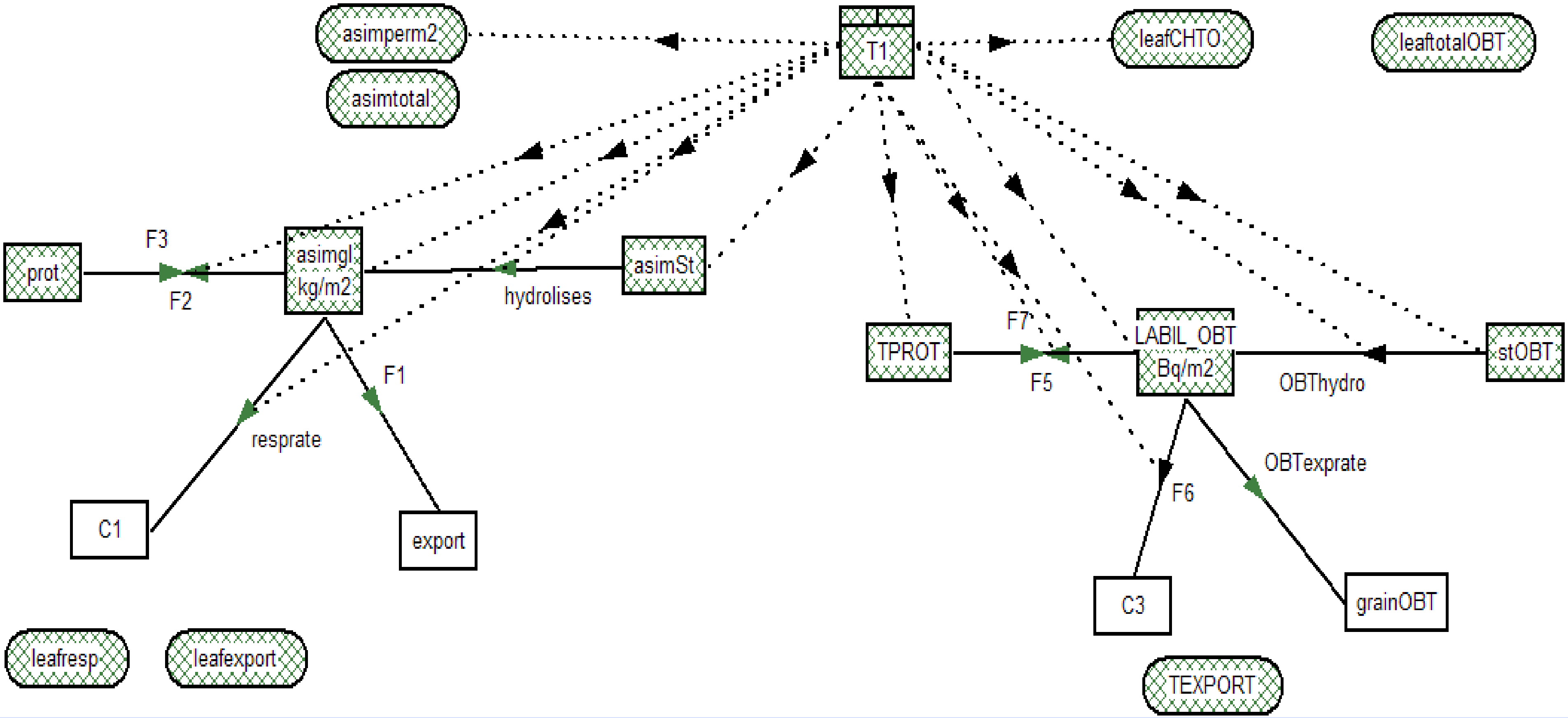
Schematic of the potential water uptake distribution function, *b(x),* in the soil root zone



HTO in soil, no rain, 24 h after application- sandy soil



FIRST ATTEMPT TO MODEL NIGHT OBT PRODUCTION: STARCH role, RESPIRATION, PROTEIN TURNOVER…..and growth



LEFT NO TRITIUM Right TRITIUM
Basic processes are similar for growth and maintenance respiration
SUBSTRATE AND STRUCTURAL MATTER

Variability of key Farquhar model parameters

```
c*  EAJMAX  R4  Energy of activation for Jmax              J mol-1   I  *
c*  XVN     R4  Slope of linearity between Vcmax & leaf N  umol/g/s  I  *
c*  XJN     R4  Slope of linearity between Jmax & leaf N   umol/g/s  I  *
c*  THETA   R4  Convexity for light response of e-transport  -       I  *
c   PARAM EAJMAX=48041.88; XVN=62.; XJN=124.; THETA=0.7   pea
c                =39600          =50.3      =100.6       =0.67  sugbeat
c                =30200          =60        =120         =0.7   s barley
c                =70890          =62        =124         =0.7   maize
c                =48270          =60        =120         =0.7   w wheat
c                =84180          =59        =118         =0.72  potato
```

MODELLING THE TRITIUM IMPACT ON THE ENVIRONMENT

Part three

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Oral talks given at UNIVERSIDAD POLITECNICA DE MADRID, May 29 2009, Madrid, Spain

IFIN-HH

IAEA
Atoms for Peace: The First Half Century
1957–2007

Research and development of environmental tritium modelling, an update

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2012 HPS Annual Meeting

Sacramento, CA

CONCLUZII

Un model robust pentru dinamica tritiului in plante agricole poate fi realizat sub urmatoarele conditii:

-O mai buna intelegere a proceselor biochimice in timpul noptii

-cunoasterea parametrilor fenologici si fiziologici ai genotipurilor ACTUAL cultivate

-O robusta predictie a factorilor meteorologici

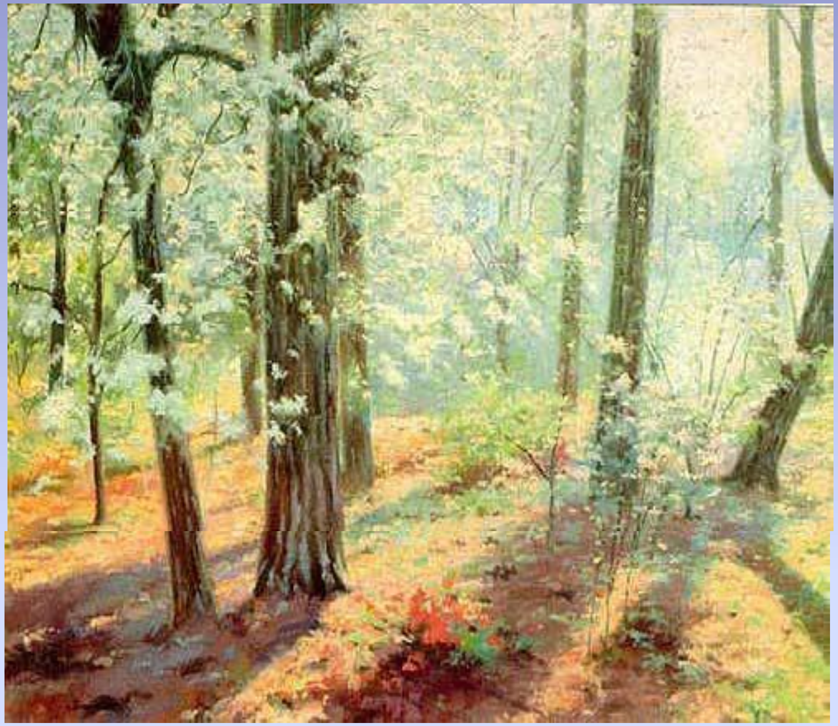
--cunosterea raspunsului planta-sol in situatii extreme

- simplificarea dupa intelegere (parsimonious model)

-SUPTAVIETUIREA CERCETARII AGRICOLE ROMANE

-IMPLICAREA IFIN-HH

-Tratarea interdisciplinara si colaborarea interNATIONALA



Alternative I

Alternative II, seceta

- **Vă mulţumesc pentru atenţie!**