

Study case 3

Meteorological indicators for yield estimation in Morocco

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The wheat model

Major phases	Start	End	Differentiation Process	Physiological process
Plant establishment	Germination	Tillering	Roots, leaves, shoots	Biomass production (Carbohydrate)
Spike development	Jointing	Heading	Spikes, spikelets, florets	Biomass production (Carbohydrate)
Grain development	Flowering	Maturity	Grain development and filling	Remobilization of carbohydrates (starch and proteins)

Grain yield = Biomass x Harvest index

Phenology and climate

Growth Stage	Period	Temperature	Water need	Growth
Planting	November	Mild (20's)	Low	Low
Tillering	January	Low (10s)	Medium	Medium
Jointing	February	Start rising (15's)	High	High
Flowering	March	Mild (20's)	Medium	Medium
Grain filling	April	High (30's)	Low	Nil
Maturity	May	High (40's)	Nil	Nil (desiccation)

In general, temperature influences development and water influences growth

Factors influencing wheat yield

Factor	Variation	Factor of variation	Sensitive stage
Water	High	Shortage of water Supplied water Excess water	Tillering, elongation Tillering, elongation Tillering, grain quality
Minerals	Medium	Soil fertility Fertilization Cultivar	Tillering, elongation Tillering, elongation Elongation
Water*temperature*minerals	High		Vegetative stage
CO2	Low	Greenhouse effect	Vegetative stage
Temperature	Low		Spike formation Grain filling
Radiation	Low	Clouds	Vegetative stage

Some basic concepts

- **Risk** is a probable loss of a measurable trait (yield, biomass, etc.);
- **Hazard** is an uncertain event (Flood, drought, epidemics, etc.);
- **Vulnerability** is the susceptibility of a crop, a land, an agro-system, etc.).

Risk can be explained by hazard alone on a large scale, downscaling needs vulnerability factors

Risk

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability}$$

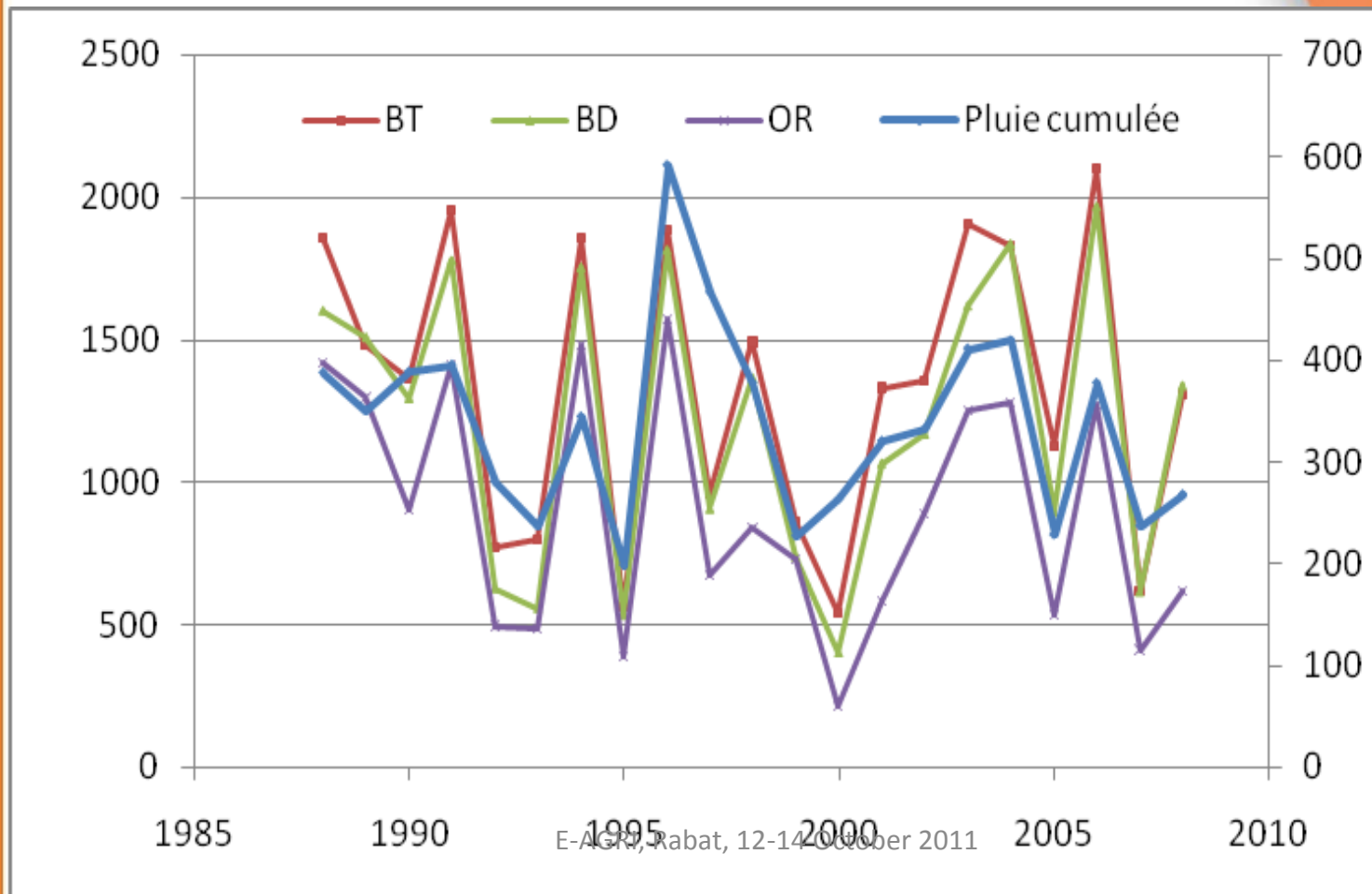
Risk = Yield, Biomass, Height, Flowering, etc.

Hazard = Rainfall, Drought, Temperature,
Mineral concentration, associated stresses like
diseases and insects, etc.

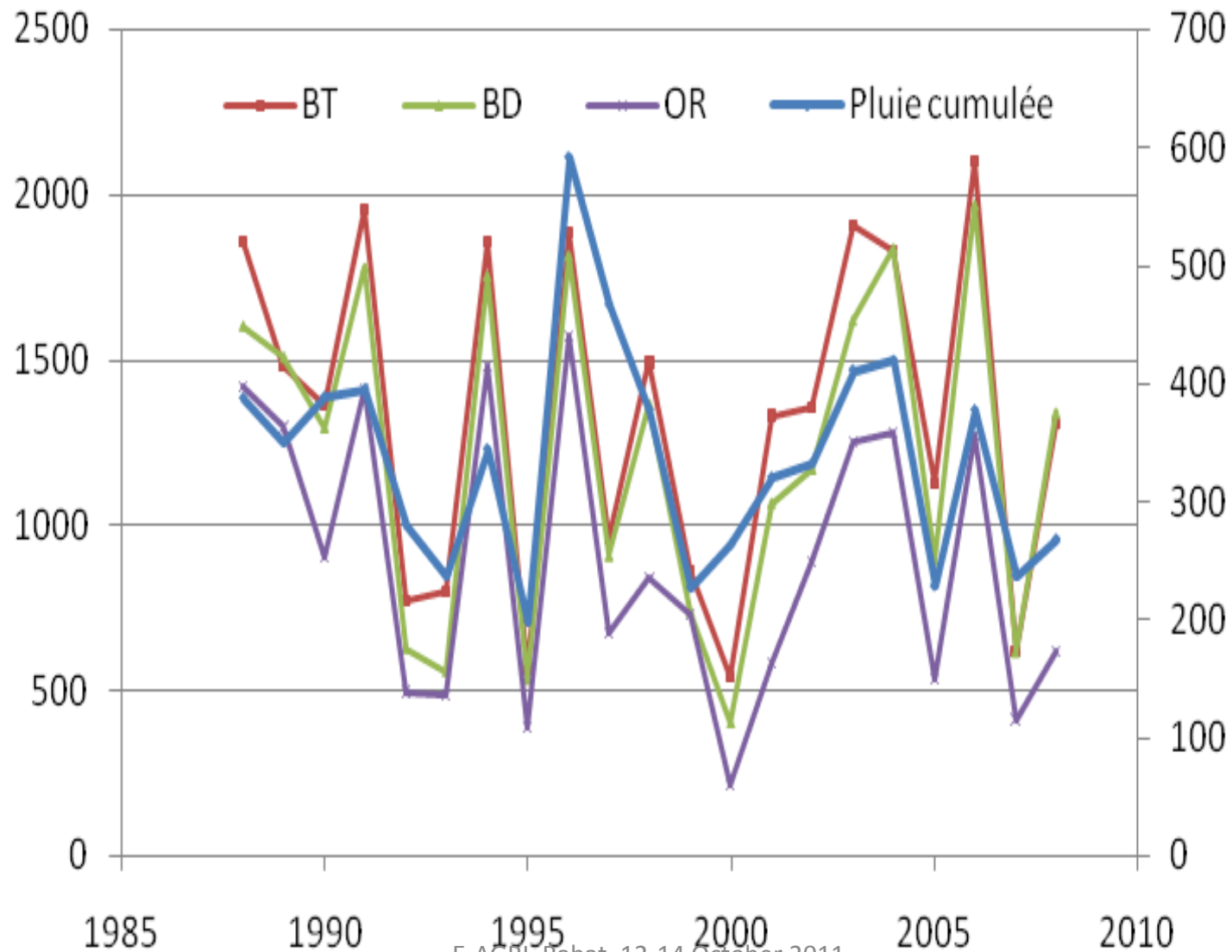
Vulnerability = Susceptibility, tolerance,
resistance, etc.

Risk grain yield

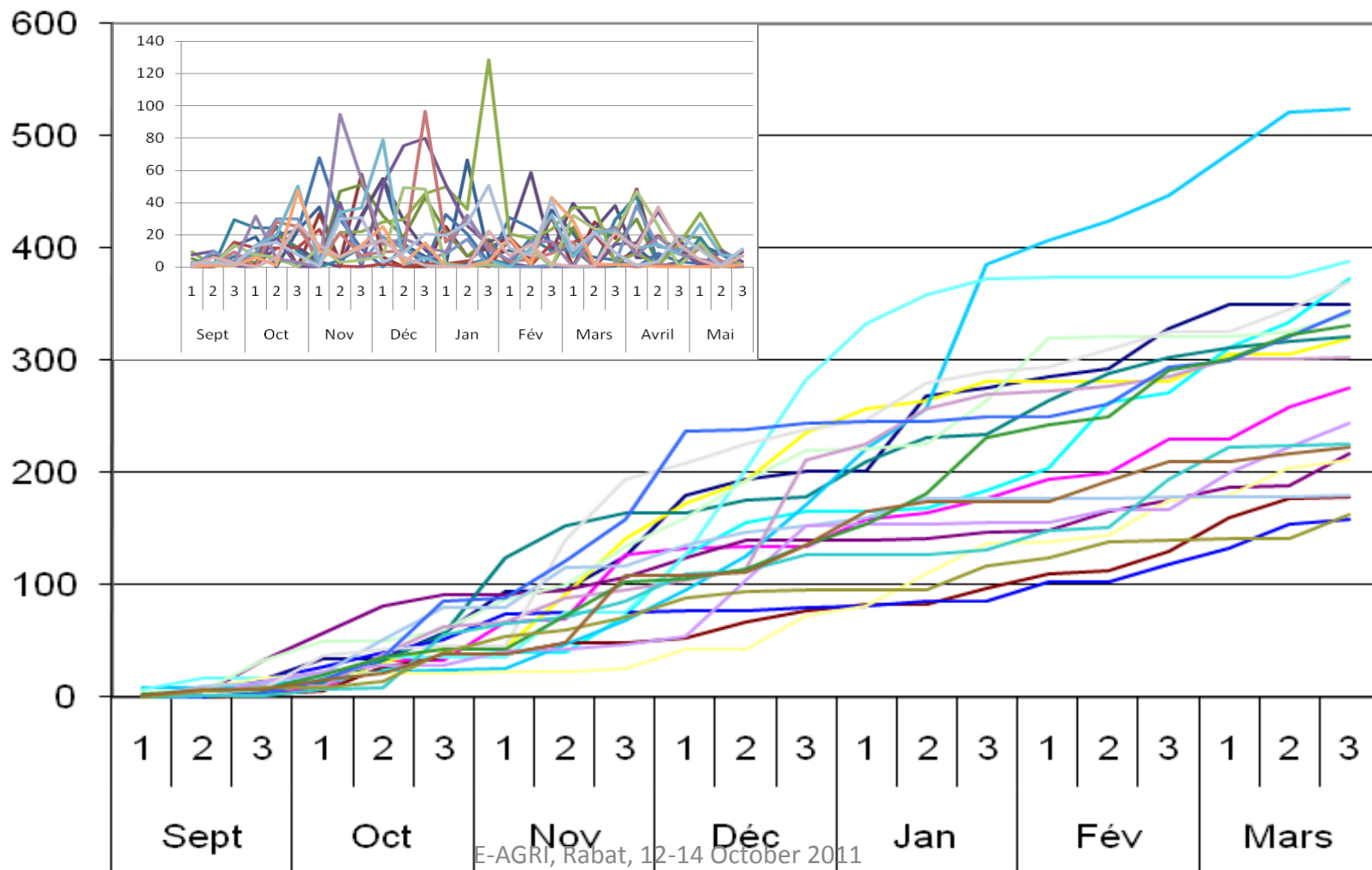
Temporal variation and Spatial variation



Correlation rainfall and yield

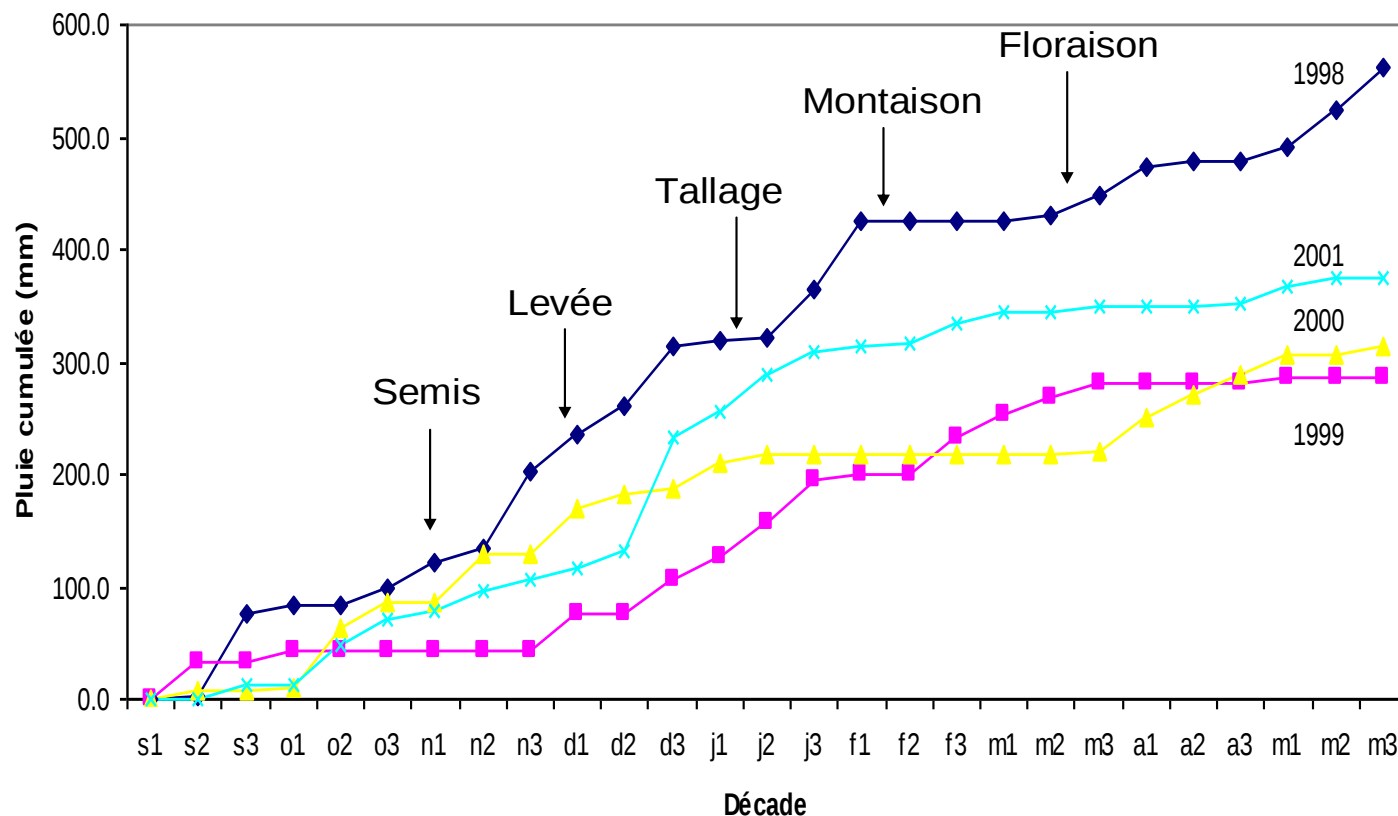


Cumulative annual rainfall



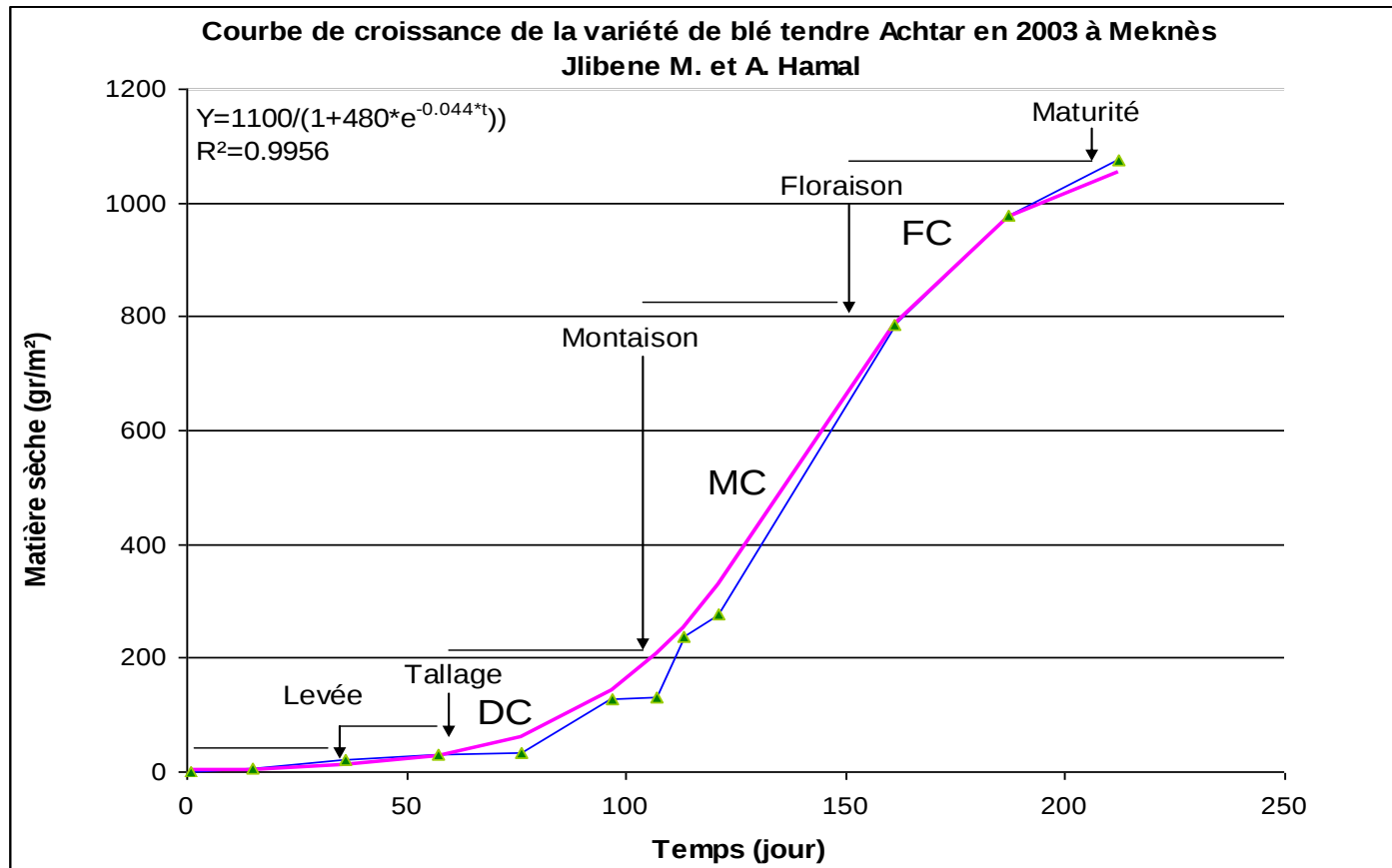
Wheat development and rainfall

Cumul de pluviométrie décadaire à Meknes, pour la période 1998-2001.



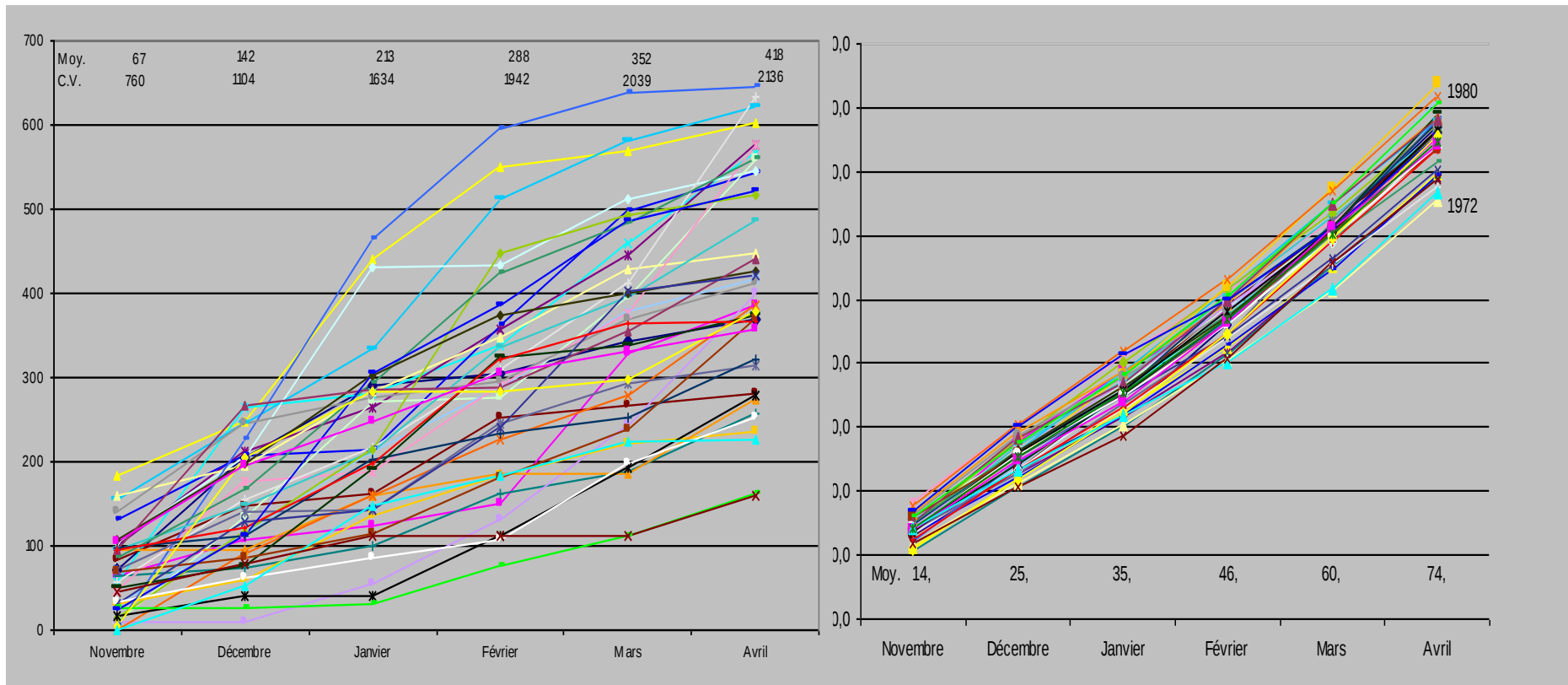
Growth stages can be predicted based on temperature

Wheat growth and development



Hazard

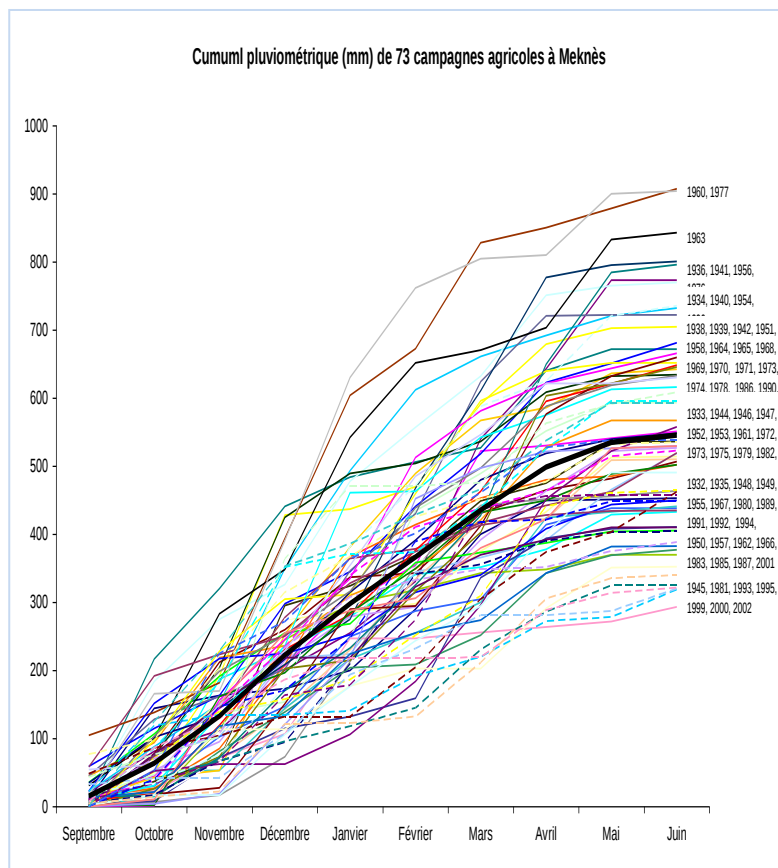
Most variable



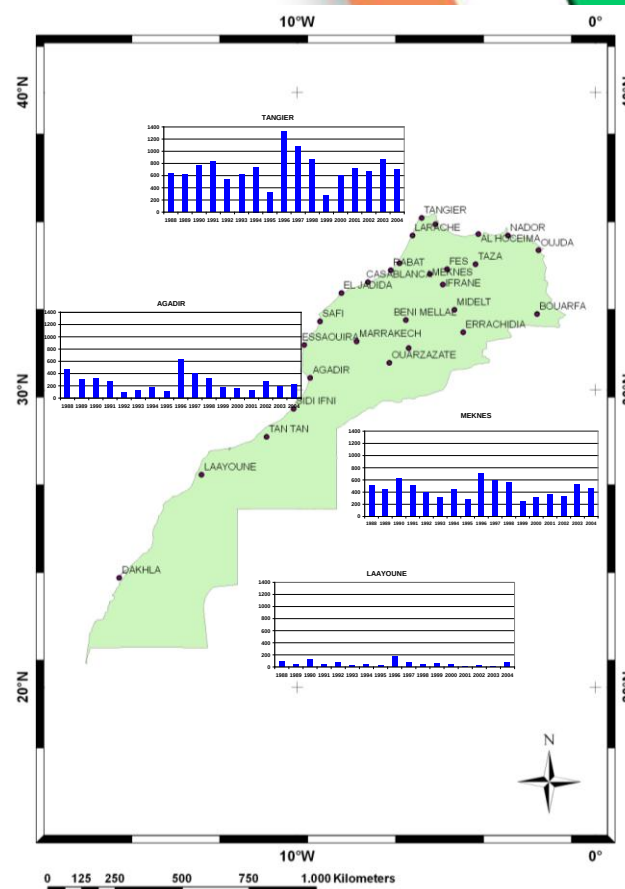
Rainfall variation

Temperature variation

Rainfall hazard



Temporal variation



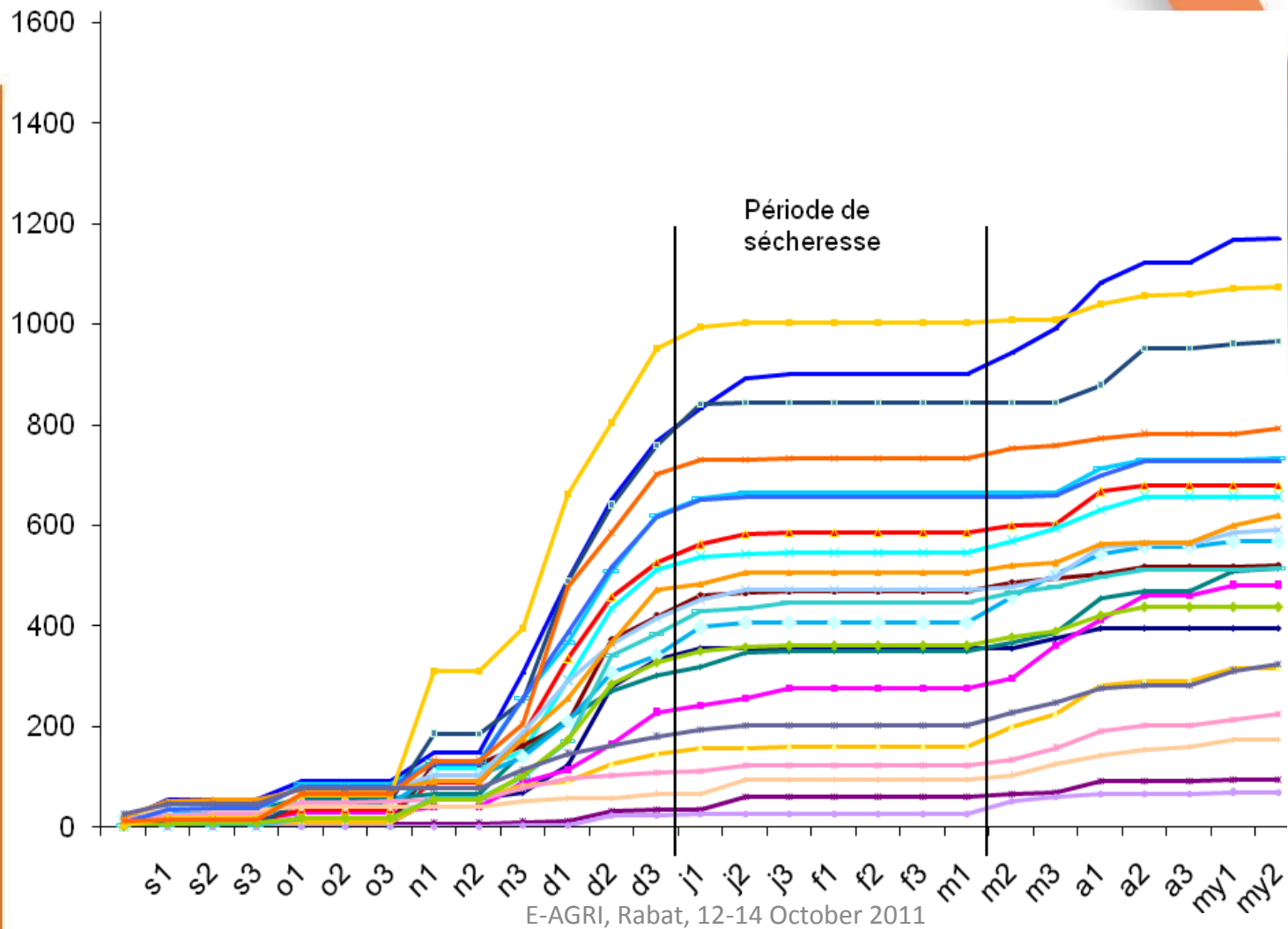
Spatial variation

Vulnerability

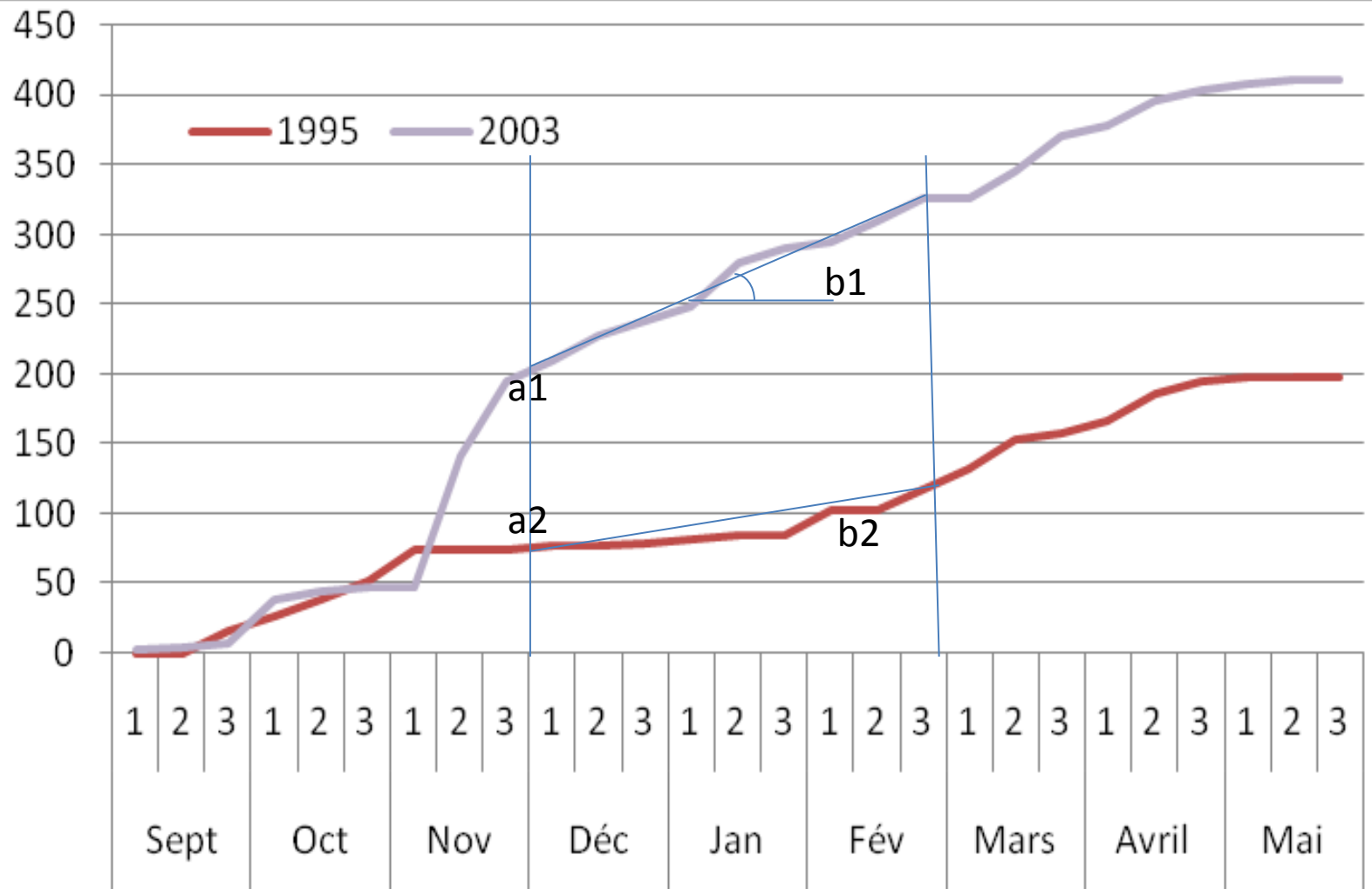
- Land (aridity, soil water holding capacity and general fertility)
- Cropping system (rotation, supplied water, fertilization)
- Crop management (planting date, weeding, pest control, etc)
- Cultivar tolerance or resistance (to drought, heat, frost, insects, viruses, minerals)



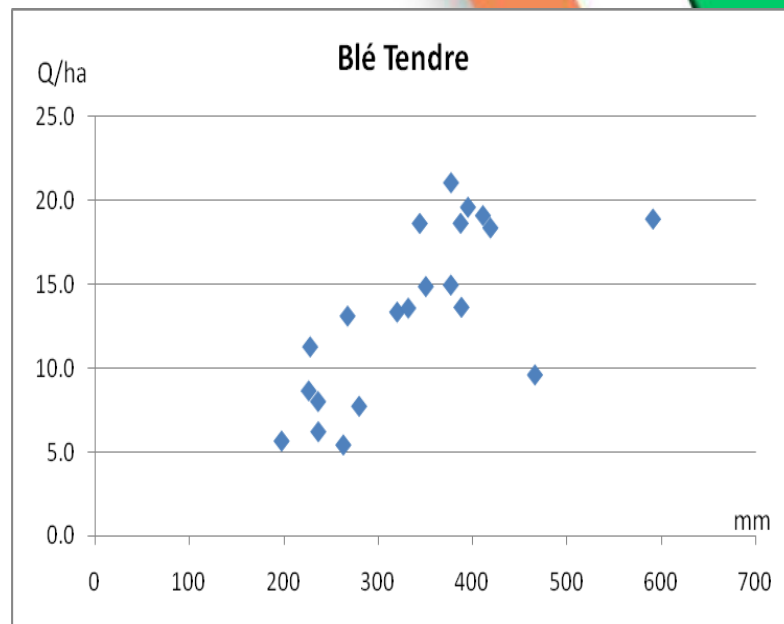
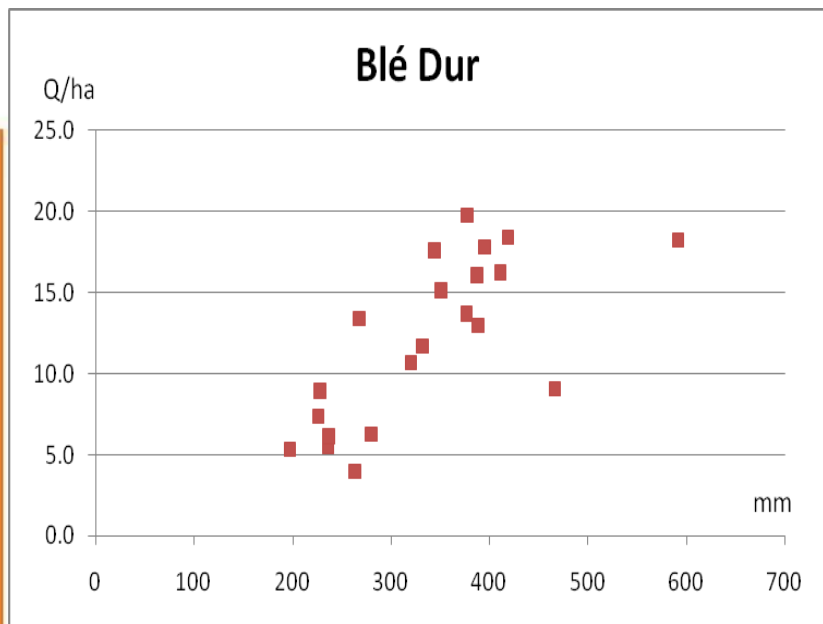
Most dangerous drought period



Two contrasting seasons for rainfall



Relation between wheat yield and rainfall



Correlation between yield of wheat and relevant rainfall (September-May) de 0,74 et 0,76 (1996 et 1997 seasons excluded)

Most significant indicators

Indicator	Risk	Hazard	Vulnerability
Rainfall	Up to 10%	Excess of rainfall	Drainage, Cultivar tolerance to flooding and/or sprouting,
Drought	Up to 80%	Shortage of rainfall	Irrigation, cultivar resistance, conservation management
Hessian fly	Up to 30%	Severity of infestation	Cultivar resistance, date of planting
Septoria	Up to 30%	Severity of infection	Time of infection, protection, resistant cultivar
Yellow rust	Up to 30%	Severity of infection	Time of infection, protection, resistant cultivar
Weeds	Up to 50%	Severity of infestation	Soil infestation, management, protection
Fertilization	Up to 70%	Quantity	Soil fertility, time of application, efficient cultivar
Planting date	Up to 60%	Days	Earliness, resistance to Hessian fly

Downscaling in yield prediction

Scale	Meteorological indicator	Vulnerability
Nation	Crop cycle rainfall, three-months rainfall	Equals unity
Agro ecological	Crop cycle rainfall, three-months rainfall	Date of planting, insect infestation, disease infection
Province	Monthly or decadal rainfall, temperature,	Level of N, cultivar
Locality	Decadal rainfall	Pests control, date of planting, weed infestation, supplemental irrigation

End of the presentation

Thank you