

# ***Systems Modelling for the Geological Storage of Carbon Dioxide***

***Defining R&D Needs to Assess Environmental  
Impacts in CO<sub>2</sub> Storage***

***16 September 2008***

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# *Presentation Outline*

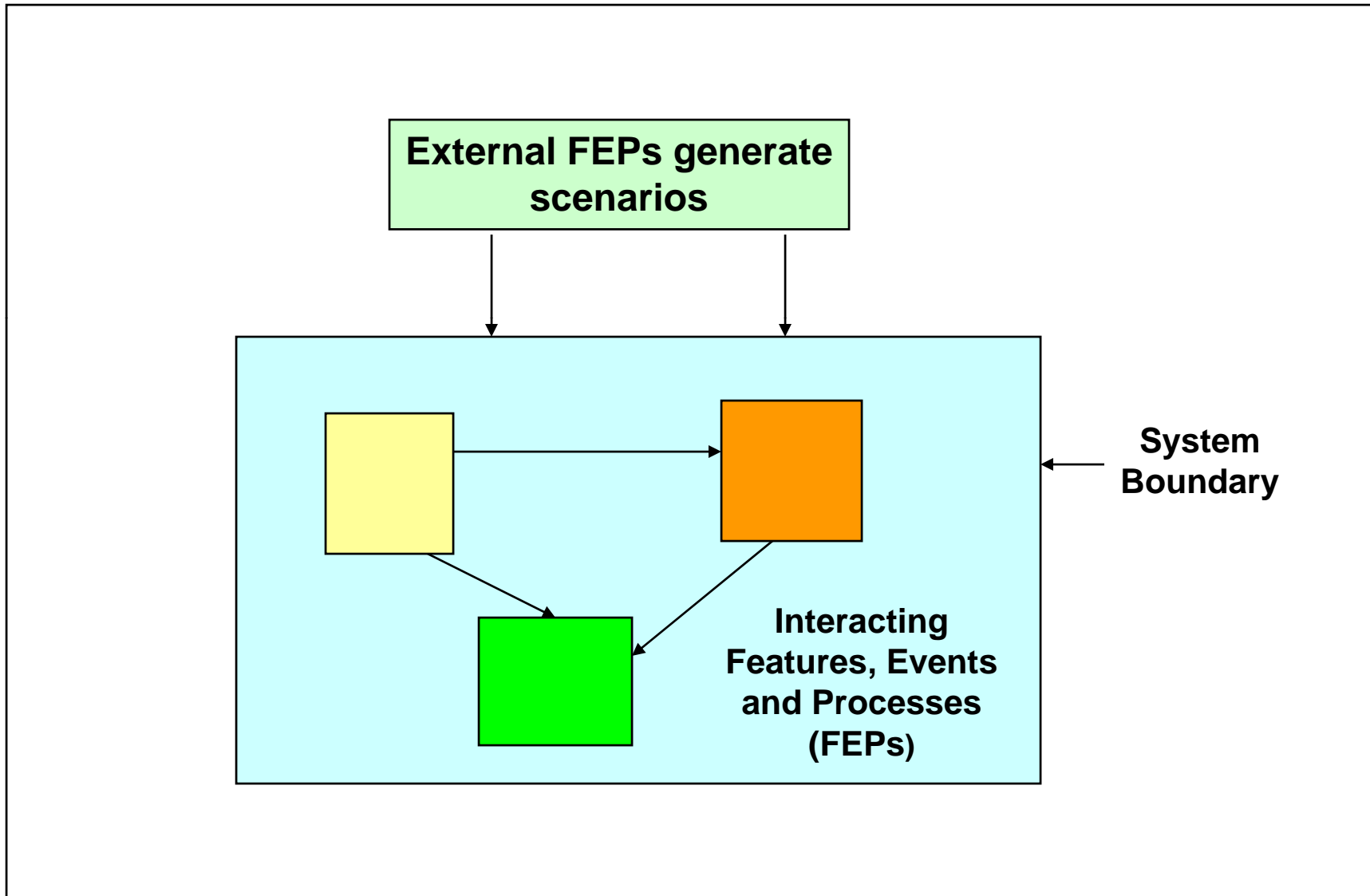
- *Review of the systems approach to modelling*
- *Some example calculations for the Latera site undertaken in collaboration with BGS and the University of Rome with funding from the UK Government (BERR)*
- *Key Issues for environmental impacts*

# *Systems Modelling*

## *FEPs*

*“A key activity in the development of performance and safety analyses is the comprehensive identification of potentially relevant factors, often termed: Features, Events and Processes (FEPs)”*

# The Systems Approach



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## Database: Generic

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Name

6.3.6 Buildings



Description

Features related to houses, or other structures or shelters, in which humans spend time.

Relevance to performance and safety

The structure or materials used in building construction be significant factors for determining potential exposure pathways to CO2 or contaminants. For example, given that CO2 is denser than air, it may accumulate in the basements/cellars of dwellings.

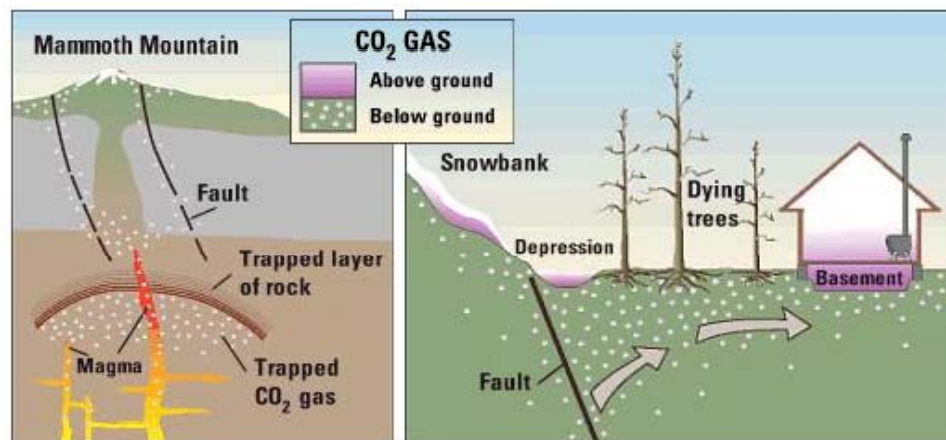


Illustration of CO2 accumulating in a basement, from the USGS Mammoth Mountain website

References

There are no references.

Links

1. [USGS Mammoth Mountain website](#)

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This record last modified: 2004-02-17.

# *Model Types*

- *Reservoir simulation models can represent in detail transport of carbon dioxide at depth*
- *'Impacts' models can represent potential consequences of carbon dioxide transport to the accessible environment*
- *Systems Models represent the important FEPs for the system as a whole, using information gained from detailed modelling of particularly <sup>LL1</sup> parts of the system*

Slide 7

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LL1

spelling

Laura Limer, 08/09/2008

# *The Use of Systems Models*

- *They can help identify key areas of **uncertainty** in the system as a whole, helping to define R&D requirements: what are the key issues for assessing potential environmental impacts for the chosen site?*
- *The **timescales** considered (typically several thousand years) will generally be much longer than those relevant to operational safety studies.*
- ***FEP audits** can be used to document how all the important issues have been dealt with.*

# *The Latera Site*

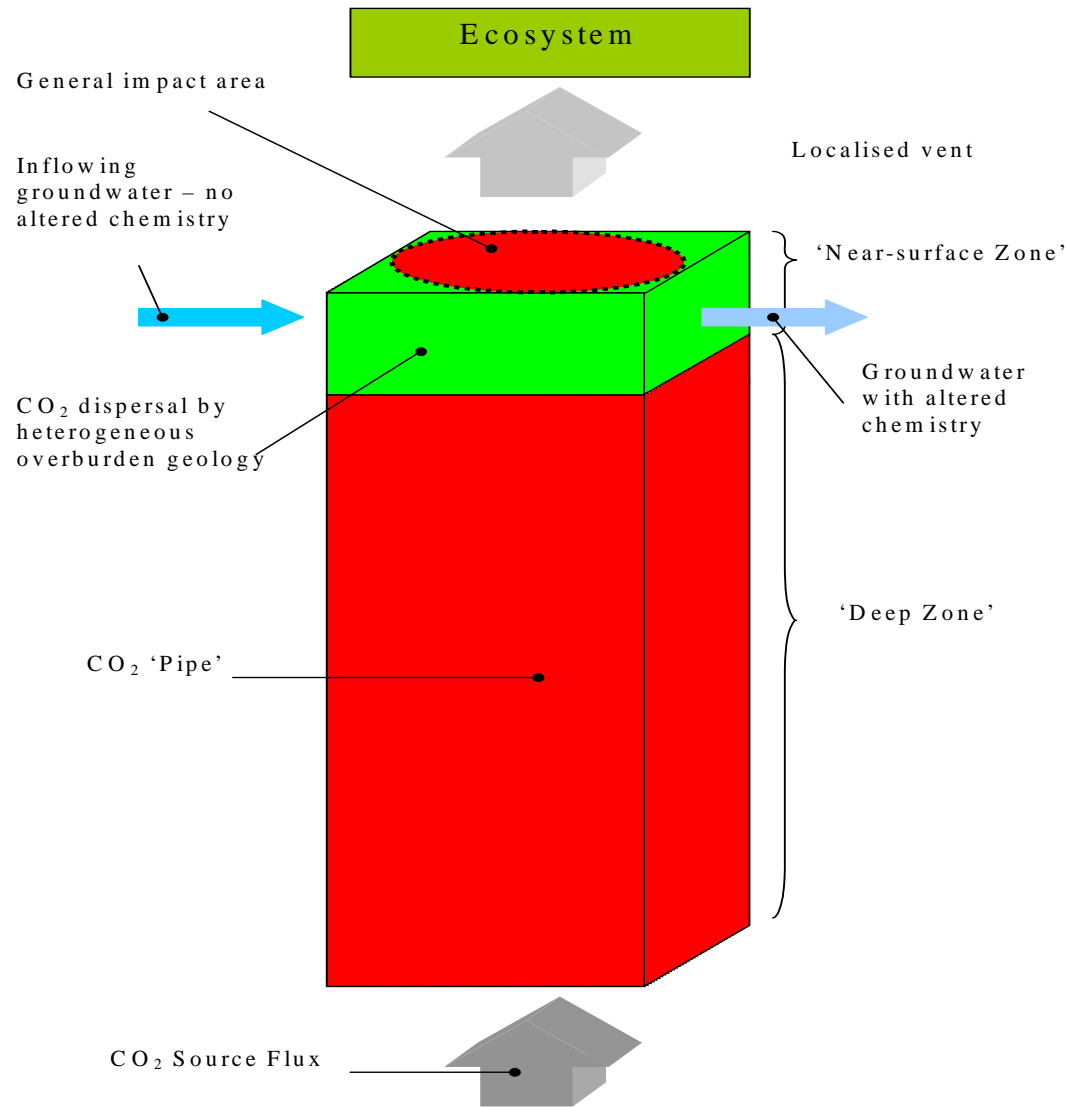
## *Why Model Latera?*

- *Latera is a natural analogue site in Italy*
- *Producing models for such sites provides valuable experience for methodology development*
- *If we can represent the key features of natural systems, this gives confidence in our ability to be able to produce models for CO<sub>2</sub> storage sites*
- *It enables us to address key issues, such as how to represent ecosystems*

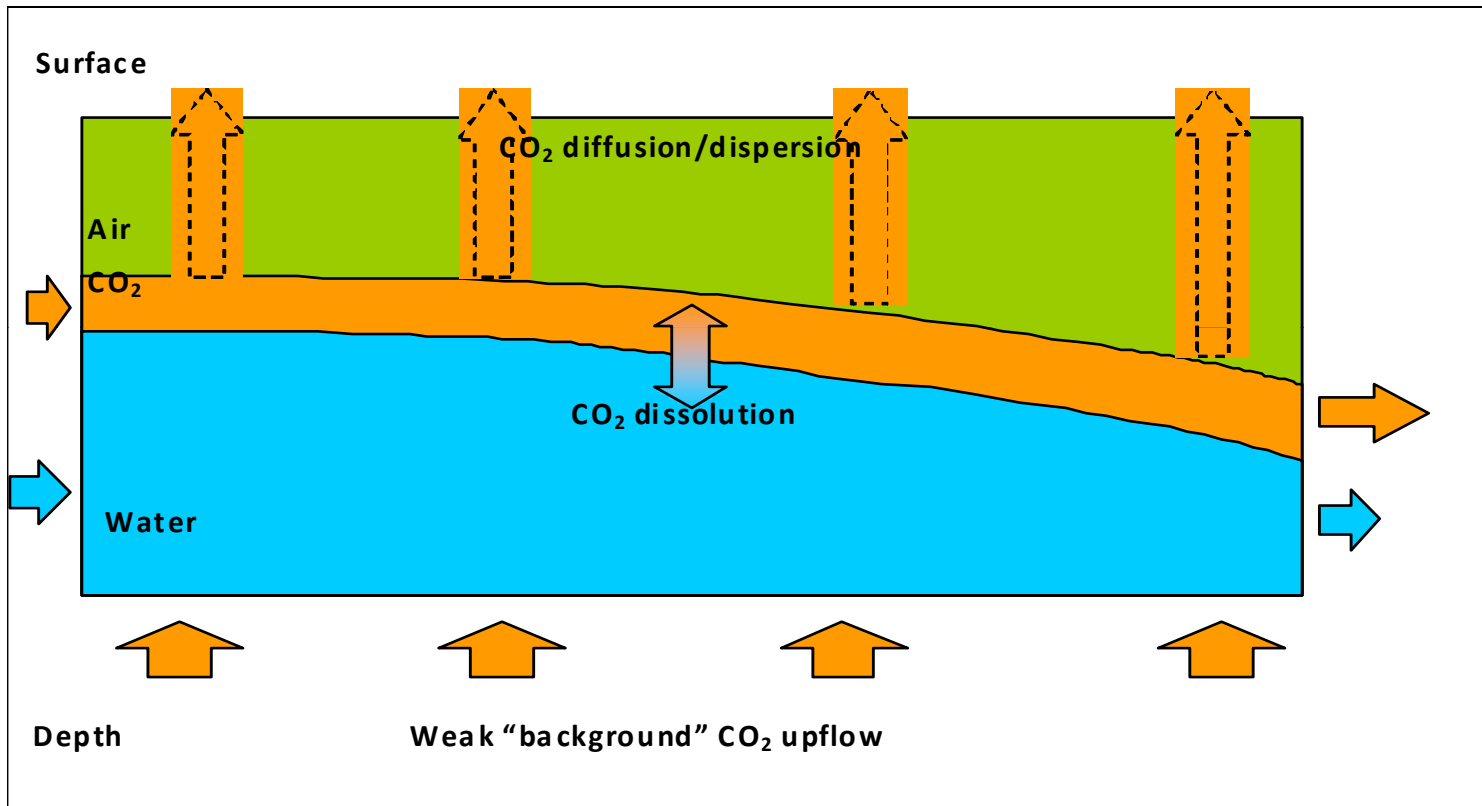
## *Example Calculations*

- *Undertaken using Quintessa's QPAC general-purpose modelling software*
- *Semi-quantitative comparisons with experience on near-surface processes*
- *Investigating the statistical distribution of vents*
- *Detailed comparisons with measurements at a single vent*

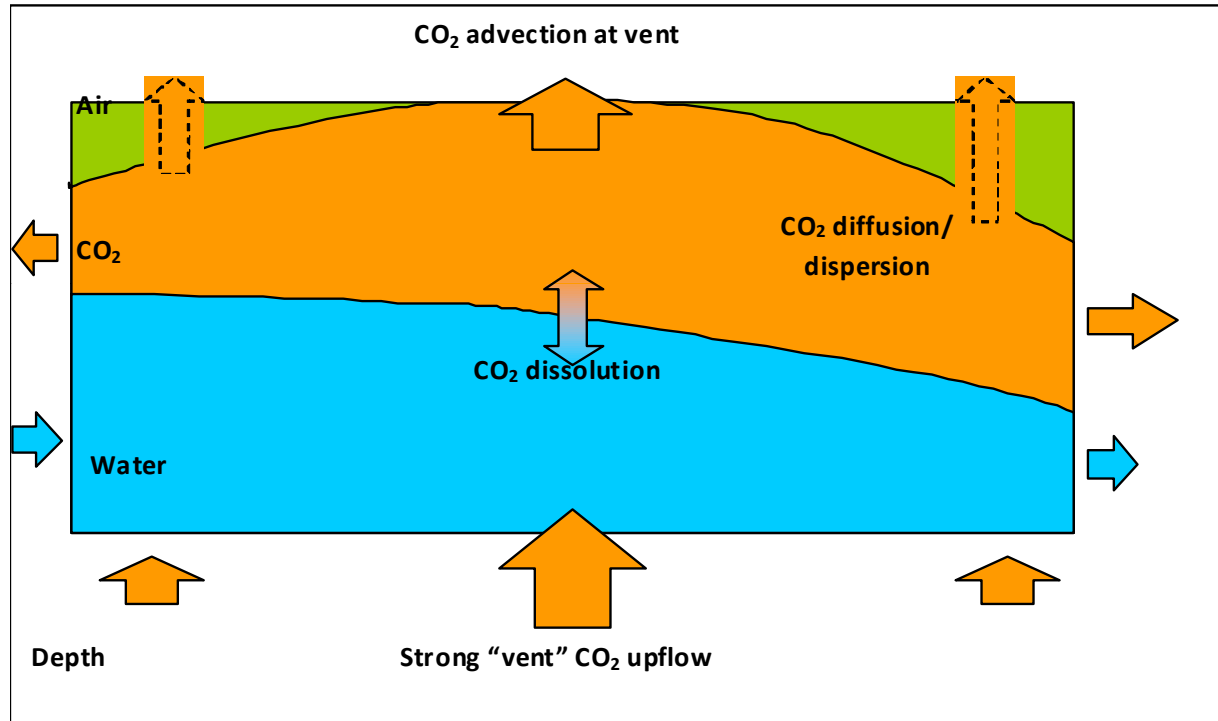
# CO<sub>2</sub> Transport at Latera



# Near-Surface Processes with a 'Weak' Geosphere Flux



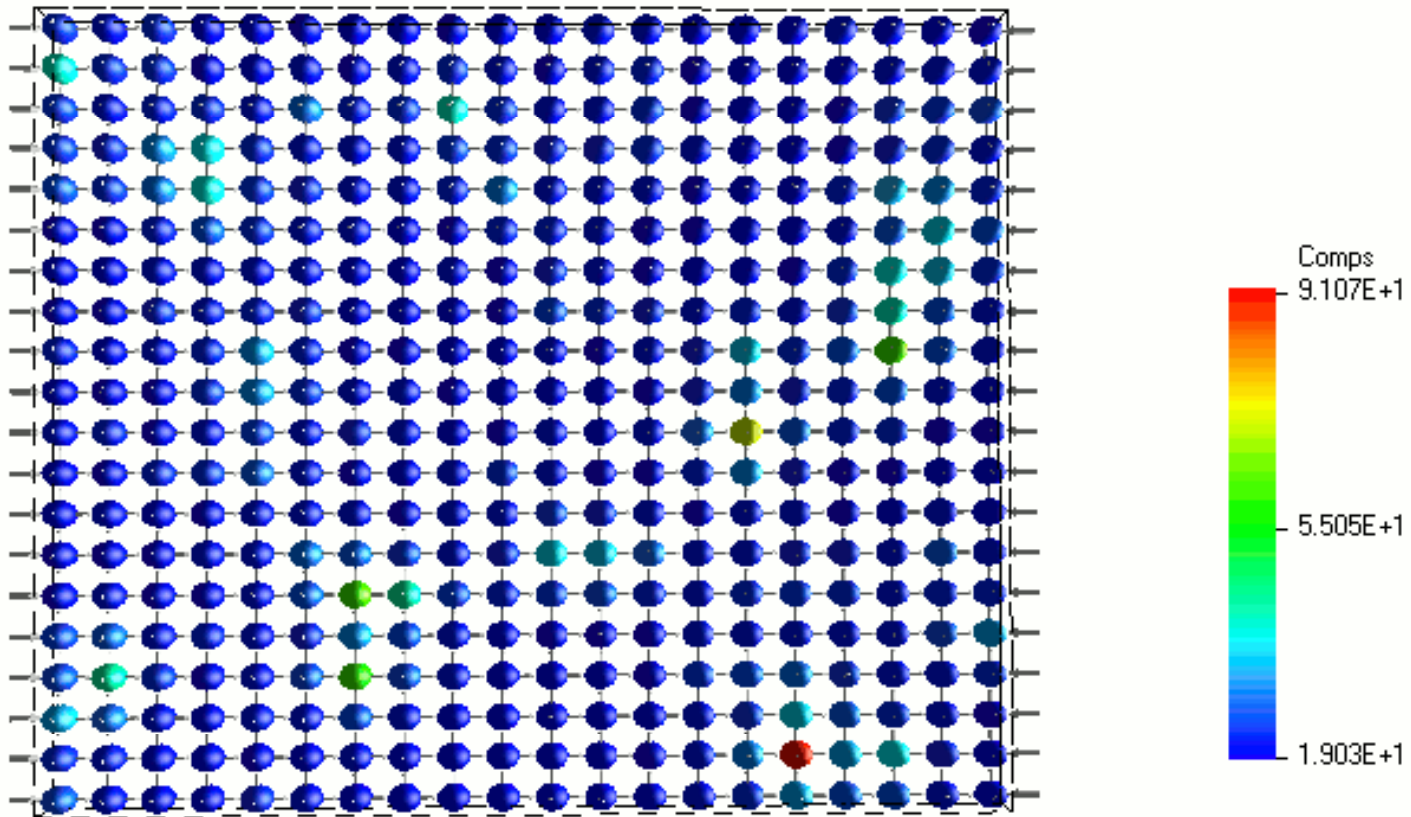
# Near-Surface Processes with a 'Strong' Geosphere Flux



## *Multi-vent Calculations*

- *A stochastically generated permeability field was used for the near-surface environment to represent heterogeneous deposits.*
- *The pattern/scale of venting is consistent with observations.*

# Calculated CO<sub>2</sub> Heads



# *Modelling the Ecosystem*

- *Currently restricted to plants*
- *The plant model represents the transport of C in the plant and soil taking account of respiration and photosynthesis*
- *Seasonal variations are included*
- *Fertilisation effects are seen first and then toxic effects are seen at higher CO<sub>2</sub> fluxes*

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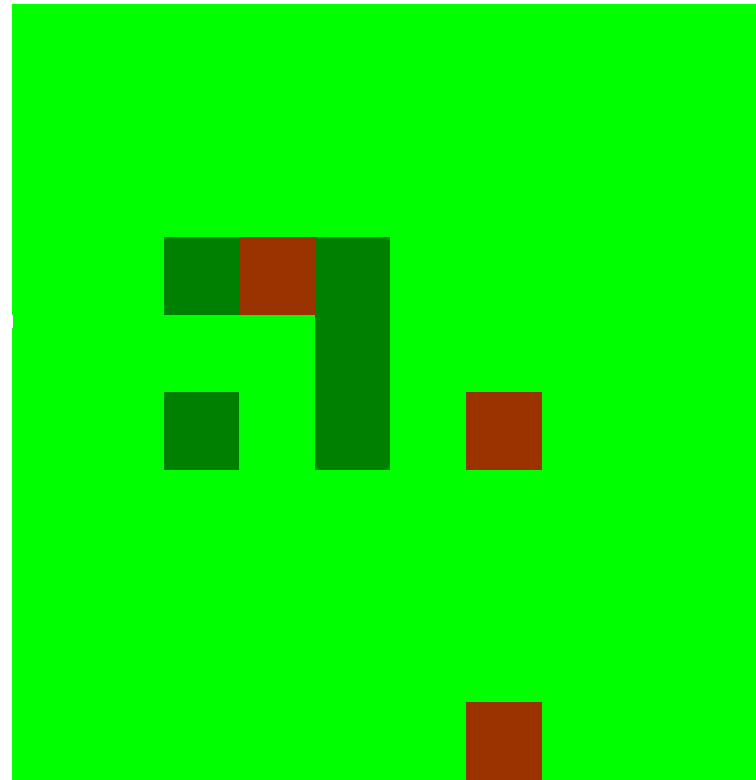
LL2

should be an 'e'

Laura Limer, 08/09/2008

# ***Illustrative Calculations: Effects on Vegetation (200m x 200m )***

LL4



***Light green = 'normal' growth***

***Dark green = fertilisation***

***Brown = reduced growth or plant death***

**Slide 18**

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**LL4**

Whilst colour choice is very logical, could be issues with any colour blind people in the audience.

Laura Limer, 08/09/2008

# Single Vent Modelling

- 6 m diameter vent, 50 m transect
- Simulated 3 locations



Site		$D_8$	$D_{11}$	$D_{48}$
SoilCO <sub>2</sub> flux (kg CO <sub>2</sub> m <sup>-2</sup> d <sup>-1</sup> )		0.25	0.11	0.002
Soil CO <sub>2</sub> concentration at various depths below the surface (%)	10 cm	34	12	0.4
	20 cm	28	19	0.3
	50 cm	62	36	1.0
	80 cm	93	87	2.0
	Simulated	37	21	0.6
Vegetation composition (%)	Full	31	62.5	100
	Die-back	25	35.0	0
	Bare	44	2.5	0
Vegetation biomass as a percentage of optimum biomass (%)	Empirical	44	80	100
	Simulated	43	77	100

## *Summary*

- *The QPAC-CO2 systems model has been able to reproduce key features of the Latera system.*
- *Further work is currently being undertaken with BGS and the University of Rome under the CO2GeoNet framework.*
- *There will be a final report at the end of the year and a paper on this topic to GHGT-9.*

*Key Issues for Environmental  
Impacts*

# Key Issues

- *We need to get more **experience** modelling whole systems. Quintessa is working on a 'generic' systems level model in the CO2ReMoVe project with the aim of subsequently applying this to specific sites.*
- *Current we don't have any clearly defined **end points** for comparison with regulatory criteria: peak local fluxes, agricultural losses, groundwater quality...?*
- *We will have to decide the appropriate **level of complexity** for terrestrial and aquatic ecosystem modelling.*