The main differences between ORCHIDEE 2.2, 3.0 and 4.3

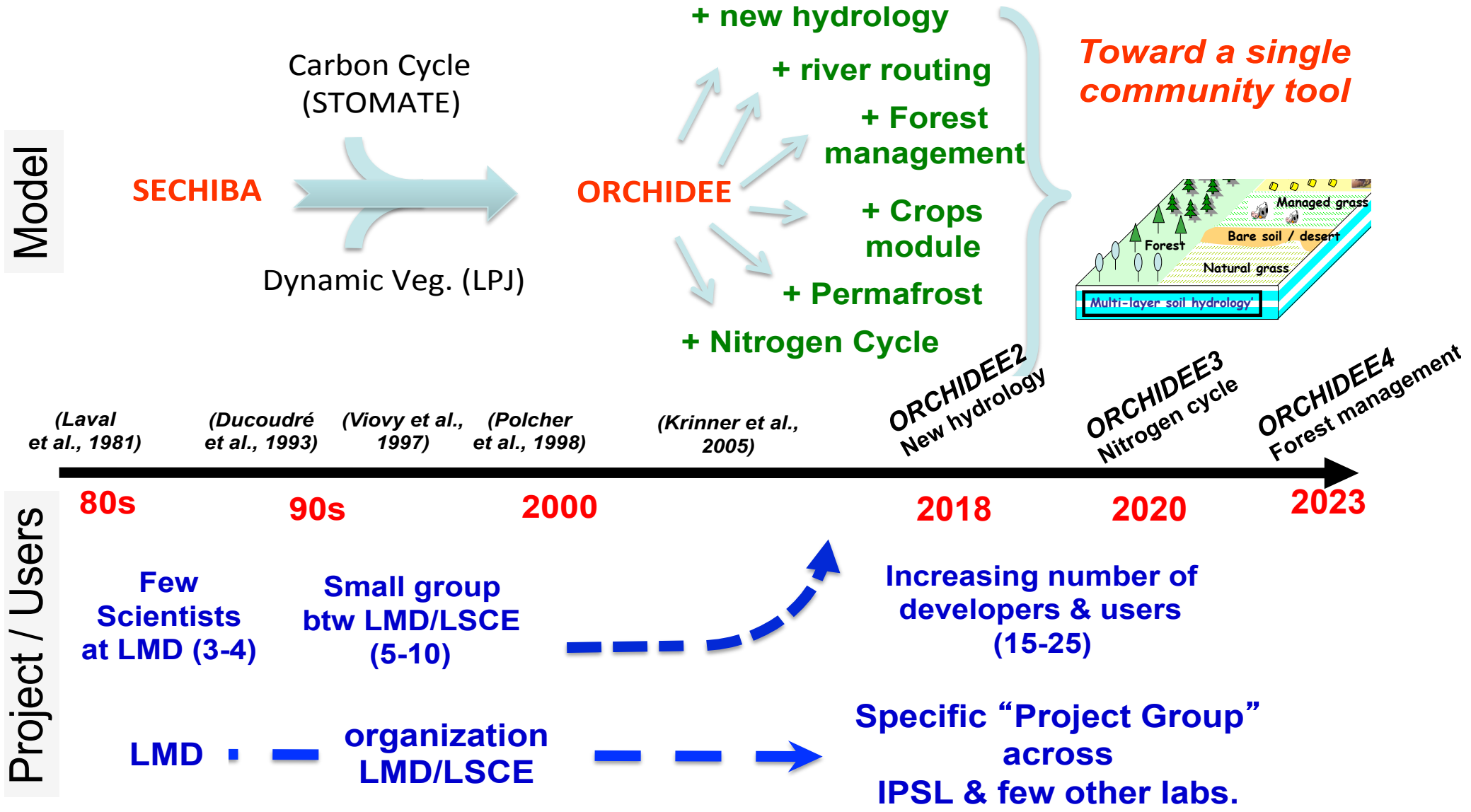
Bertrand Guenet

9/2/23

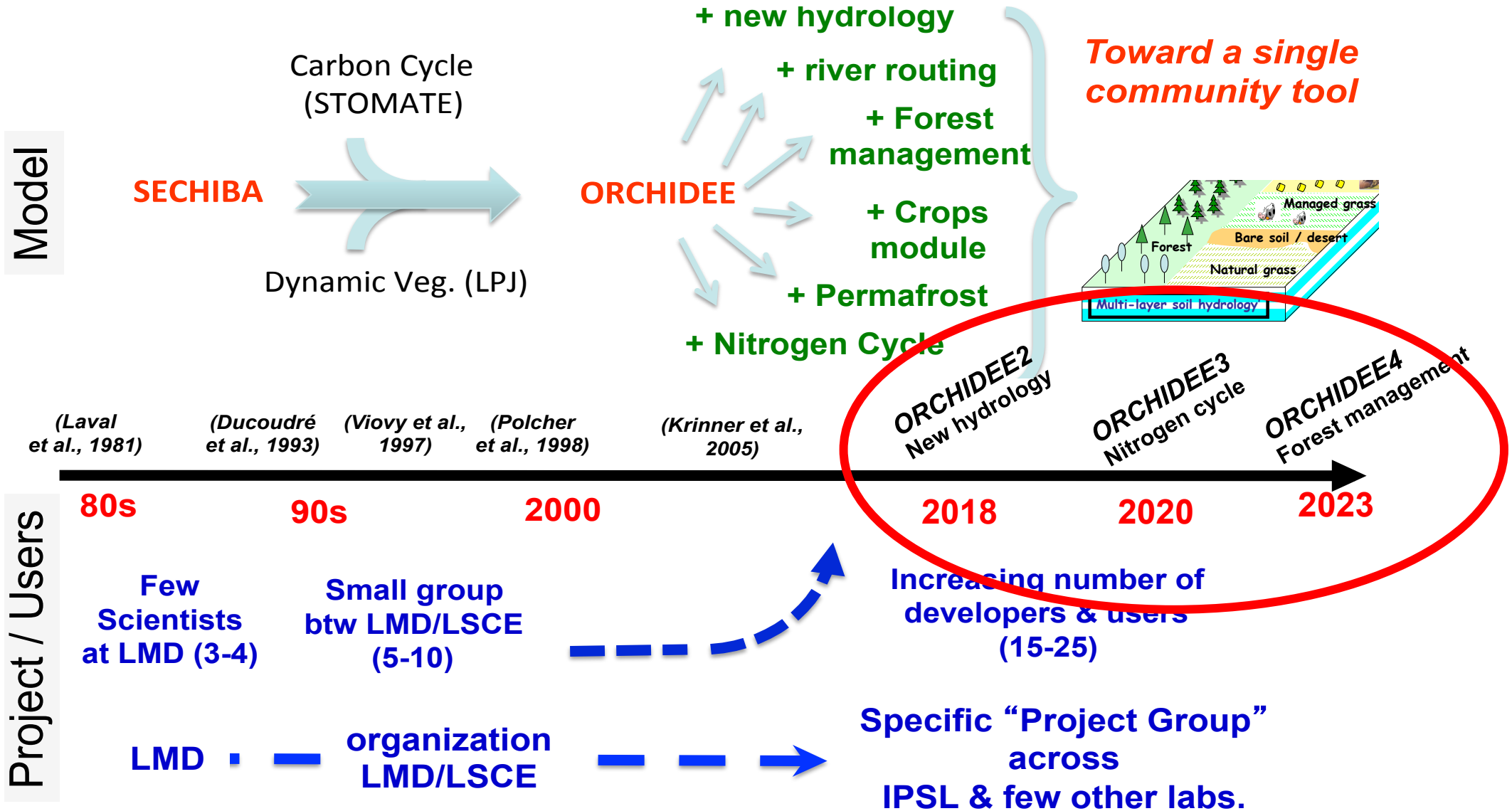
ORCHIDEE

LAND SURFACE MODEL

The history of the model



The history of the model



THE ENERGY BUDGET

Change in albedo : Background albedo

ORCHIDEE 2.2 and ORCHIDEE 3.0

- Background albedo calculated by the weighted albedo of the snow-covered and snow-free fractions of the grid cell; the snow-free background **albedo is based on the MODIS albedo product.**

ORCHIDEE 4.3

- Background albedo calculated by the weighted albedo of the snow-covered and snow-free fractions of the grid cell; the snow-free background albedo is **calculated at the PFT level and is based on the JRC-TIP product** (Pinty et al., 2011a, b) which also makes use of the MODIS albedo product

Change in albedo : Snow albedo

ORCHIDEE 2.2 and ORCHIDEE 3.0

- Snow albedo is calculated separately for each PFT and ranges between the fresh snow albedo and the old snow albedo. The transition within this range depends on the simulated snow.

ORCHIDEE 4.3

- Need to distinguish between the near infra red and the visible short wave bands.

Change in albedo : vegetation albedo

ORCHIDEE 2.2 and ORCHIDEE 3.0

- PFT specific parameter.

ORCHIDEE 4.3

- A multiple canopy levels radiative transfer scheme through the (McGrath et al.,2016). This approach accounts forthe vertical and horizontal distribution of the leaf mass as well as the solar angle.

Change in Snow coverage

ORCHIDEE 2.2 and ORCHIDEE 3.0

- The fraction of snow on vegetated surfaces is calculated from the simulated **snowdepth and snow density**. The fraction of snow on non-biological surfaces is calculated as a function of the simulated snow mass and the fixed parameters critical snow depth and critical snow density

ORCHIDEE 4.3

- The radiation scheme of Pinty et al.(2011a) requires snow to be put on **the soil below the canopy instead of on the canopy itself**. The calculation of the snow coverage of a PFT was revised according to the scheme of Yang et al. (1997), which allows for snow to completely cover the ground at depths greater than 0.2 m.

Change in radiation scheme

ORCHIDEE 2.2 and ORCHIDEE 3.0

- The fraction of the incoming short wave radiation absorbed by each layer is calculated based on the **Beer-Lambert extinction law** driven by the leaf area and as-suming an extinction coefficient fixed to 0.5 across PFTs.

ORCHIDEE 4.3

- A multiple canopy levels stream radiative transfer scheme (McGrath et al.,2016) is used to calculate the absorbed, reflected and transmitted radiation at **each level in the canopy and underneath the canopy.**

Most of the energy budget is calculated the same way

THE WATER CYCLE

Change in plant water stress

ORCHIDEE 2.2 and ORCHIDEE 3.0

- The soil water stress factor is calculated for each soil layer and each soil column separately. For each soil layer, **water stress is maximal** if the soil water content is less than the **wilting point**. **Minimal stress** is expected when soil water content is well below **soil water saturation**.

ORCHIDEE 4.3

- The initial calculation of the soil water stress has not been changed compared to ORCHIDEE v2.2 and v3.0 but the weighting of the soil water stress by the rooting profile has been replaced by an approach in which the plant stress **is determined by the wettest soil layer.**

Most of the hydrology is calculated the same way

THE BIOGEOCHEMISTRY

Change in allocation

ORCHIDEE 2.2

Plants allocate carbon to their different tissues in response to external limitations of water, light and nitrogen availability. When the ratios of these limitations are out of bounds, prescribed allocation factors are used.

ORCHIDEE 3.0

Allocation respects the pipe model theory -> producing one unit of leaf mass requires a proportional amount of sapwood to transport water from the roots to the leaves as well as a proportional fraction of roots to take up the water from the soil. The implementation of carbon and nitrogen allocation largely follows the work by Zaehle and Friend (2010).

ORCHIDEE 4.3

The allocation scheme in ORCHIDEE v3.0 is extended to simultaneously allocate C and N to several diameter classes within a forest plant functional type while accounting for intra-stand competition.

Change in mortality and turnover

ORCHIDEE 2.2

All biomass pools have a turnover time resulting in a continuous mortality at equilibrium. Following biomass turnover, biomass is transferred to the litter pool and litter is decomposed or transferred to the soil pool.

ORCHIDEE 3.0

Similar to ORCHIDEE 2.2

ORCHIDEE 4.3

Woody biomass no longer has a turnover pool. Trees are killed through self-thinning, harvest or natural disturbances.

Change in N cycle in the plants

ORCHIDEE 2.2

No N cycle

ORCHIDEE 3.0

The nitrogen cycle is simulated at the PFT level and for each carbon pool there is a corresponding nitrogen pool, with C:N ratios evolving through time. The leaf C:N ratio is dynamic and depends on the nitrogen supply by roots and demand for biomass allocation.
The C:N ratio of the other pools is driven by the C:N ratio of the leaves but modified by a pool dependent factor.

ORCHIDEE 4.3

Similar to ORCHIDEE 3.0

Change in N cycle in the soil

ORCHIDEE 2.2

No N cycle

ORCHIDEE 3.0

Decomposition of soil organic matter follows the scheme of Parton et al. (1993) in which C:N ratios of the active, slow, and passive soil organic matter pools are expressed as a function of the total mineral nitrogen content of the soil.

The mineral N can be immobilized to decompose soil C, uptake by the plants or enter the nitrification/denitrification cycle.

ORCHIDEE 4.3

Similar to ORCHIDEE 3.0

Change in phenology

ORCHIDEE 2.2

For every dormant deciduous PFT, a daily check tests whether the conditions are suitable for leaf onset depending on the meteorological conditions of the last days, weeks or months.

At leaf onset, the reserve and labile carbon pools support the growth of an initial mass of leaves and roots, and the plant is declared to be in its growing season.

If the reserve and labile carbon pools are empty, leaf onset cannot occur and the PFT dies.

ORCHIDEE 3.0

At leaf onset, the reserve and labile carbon and nitrogen pools are jointly taken into account to calculate the initial mass of leaves and roots.

ORCHIDEE 4.3

Similar to ORCHIDEE 3.0

Change in photosynthesis

ORCHIDEE 2.2

C3 and C4 photosynthesis is calculated following Farquhar et al. (1980) and Collatz et al. (1992). The number of vertical canopy layers is determined by considering the total leaf area and assuming that each canopy layer contains an LAI of 0.5.

ORCHIDEE 3.0

The nitrogen limitation on photosynthetic activity is accounted for by making Vcmax a function of the leaf Nitrogen. No changes in the vertical discretisation of the canopy.

ORCHIDEE 4.3

No changes in the calculations of C3 and C4 photosynthesis. The number of canopy layers is set to 10 where the LAI contained in each layer depends on the canopy depth which in turn depends on the tree height.

Change in litter biogeochemistry

ORCHIDEE 2.2

Prescribed fractions of the different plant components go to the metabolic and structural litter pools following senescence, turnover or mortality.
The decay of metabolic and structural litter is controlled by temperature and soil
or litter humidity.
For structural litter, its lignin content also influences the decay rate.

ORCHIDEE 3.0

If there is insufficient N available to support the decomposition of the litter and soil carbon, heterotrophic respiration will be adjusted in line with the available nitrogen

ORCHIDEE 4.3

Similar ORCHIDEE 3.0

Change in specific leaf area

ORCHIDEE 2.2

ORCHIDEE relies on a PFT-specific but fixed parameter called specific leaf area and defined as defined as the leaf area divided by the leaf mass.

ORCHIDEE 3.0

Specific leaf area at the bottom of the canopy was assumed to be fixed.
Specific leaf area was calculated as a function of the total leaf mass and an extinction coefficient

ORCHIDEE 4.3

Similar to ORCHIDEE 3.0

Change in age and diameter classes

ORCHIDEE 2.2

Not available

ORCHIDEE 3.0

Not available

ORCHIDEE 4.3

Age and diameter classes were introduced to simulate biogeochemical and biophysical heterogeneity from mortality, regrowth of forests following stand replacing disturbances such as natural disturbances, forest management, and land cover changes.

In summary

- Other **differences** not detailled here
- Most of the features of ORCHIDEE 2.2 are also in the other versions but **interactions are more dynamic**.
- Depending on your short term objectives you may choose one specific version but **ORCHIDE 4.3 will be the main version soon**.
- If your developments are merged in one version be sure to **let the group know** to not loose your development in the other versions.