« High » resolution Miocene simulations (1.4° x 0.7°) with LMDZ5A2, LMDZ6 and LMDZ6_OR : which model to use to estimate hominid environments ?

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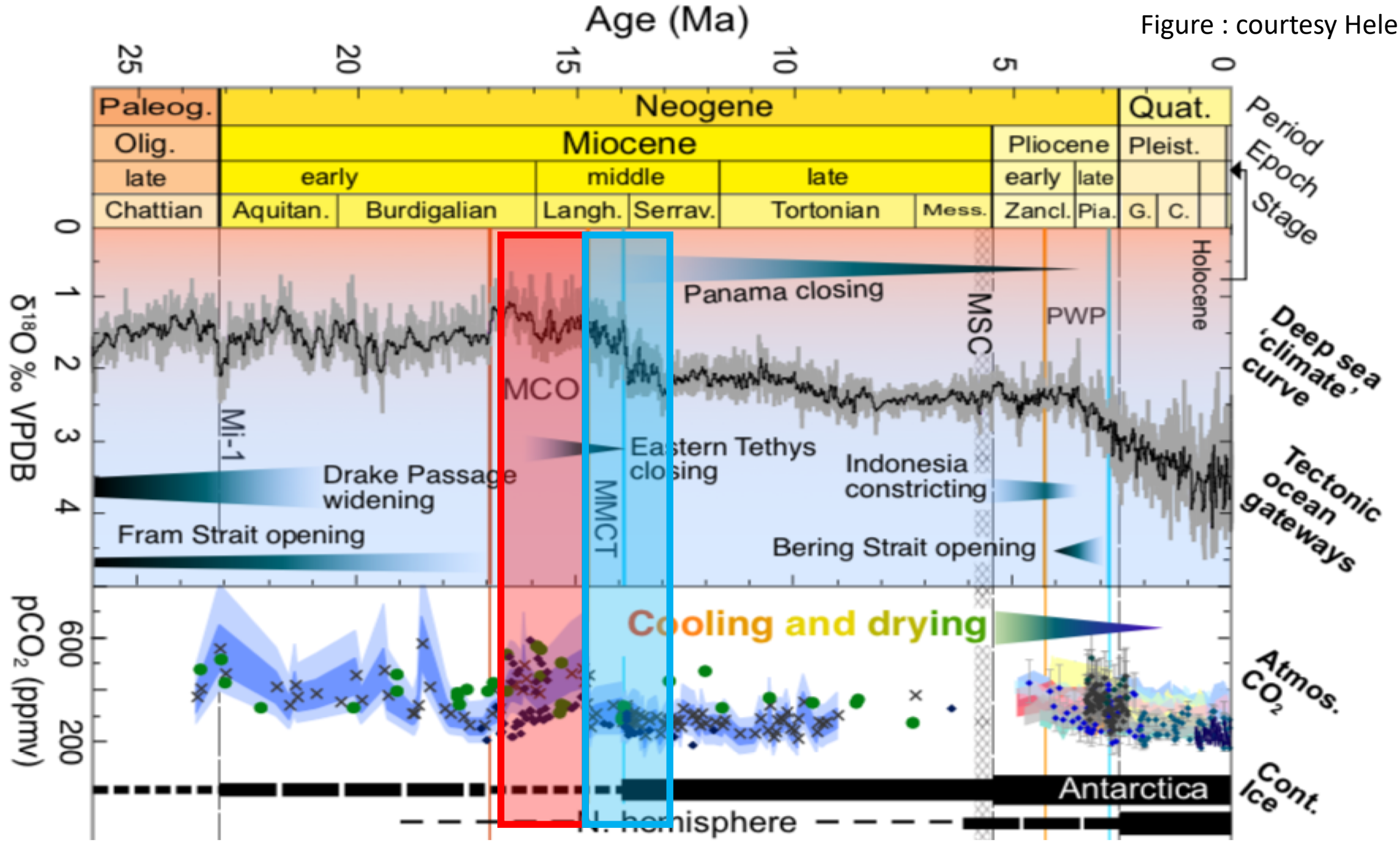
Jean-Baptiste Ladant, Anta-Clarisse Sarr

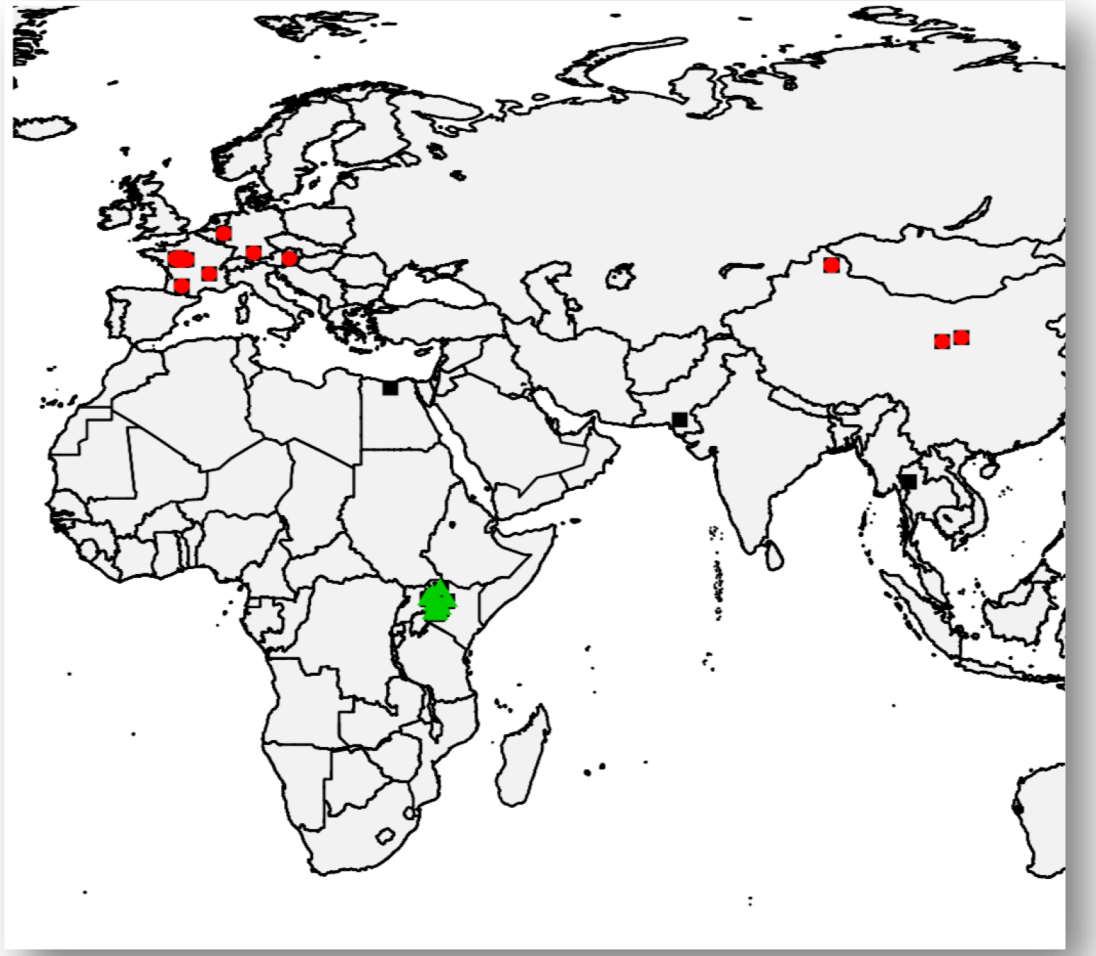


Figure : courtesy Helen Coxall

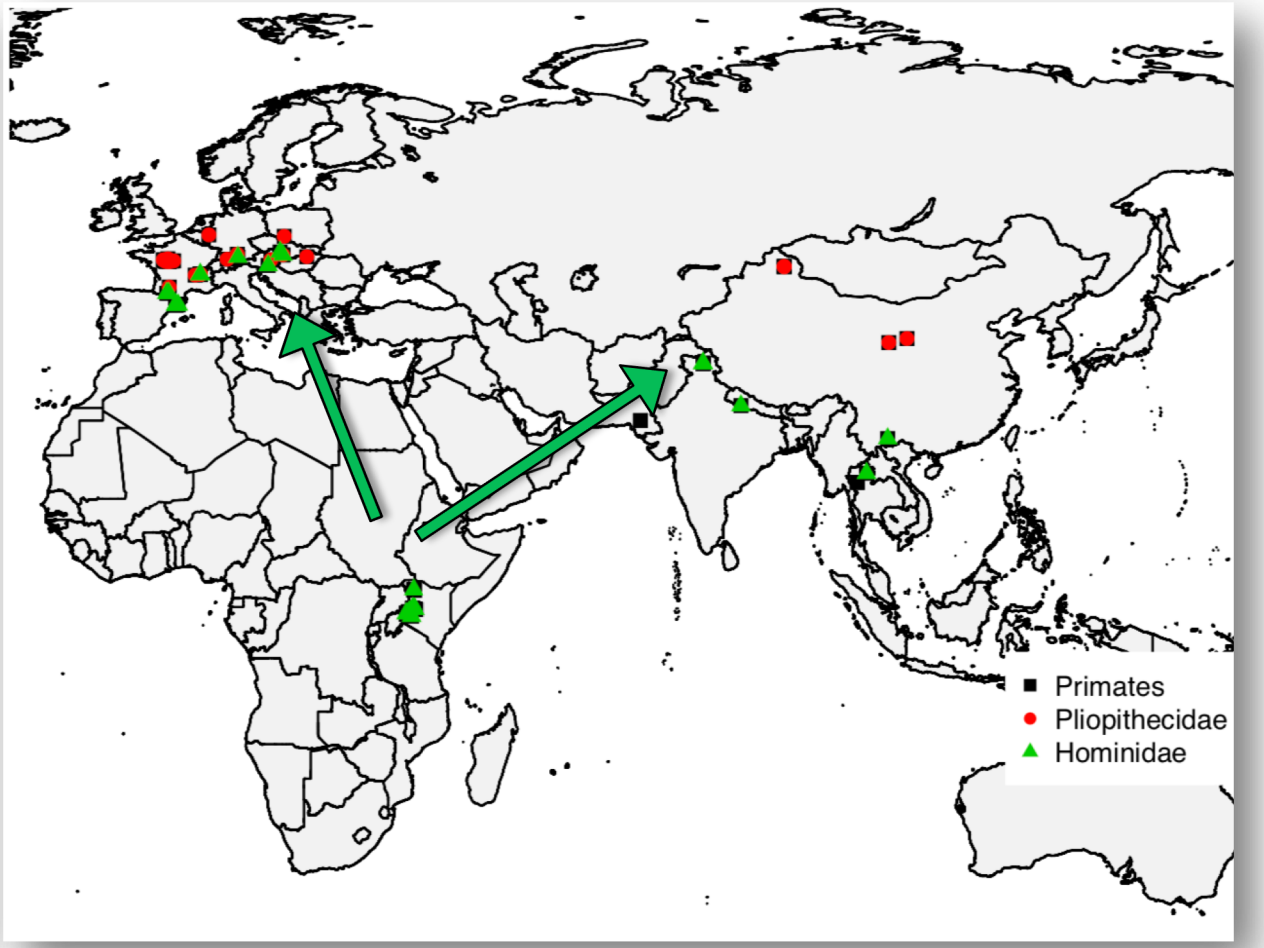


Can climate explain the distribution of Miocene apes ?

18-15 Ma (~Miocene Climate Optimum)



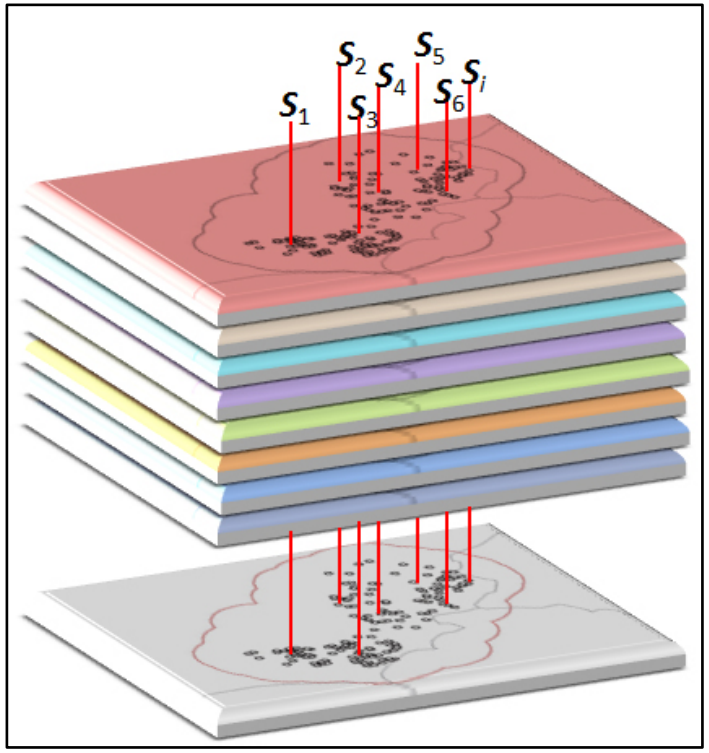
15-12 Ma (~middle Miocene Climate Transition)



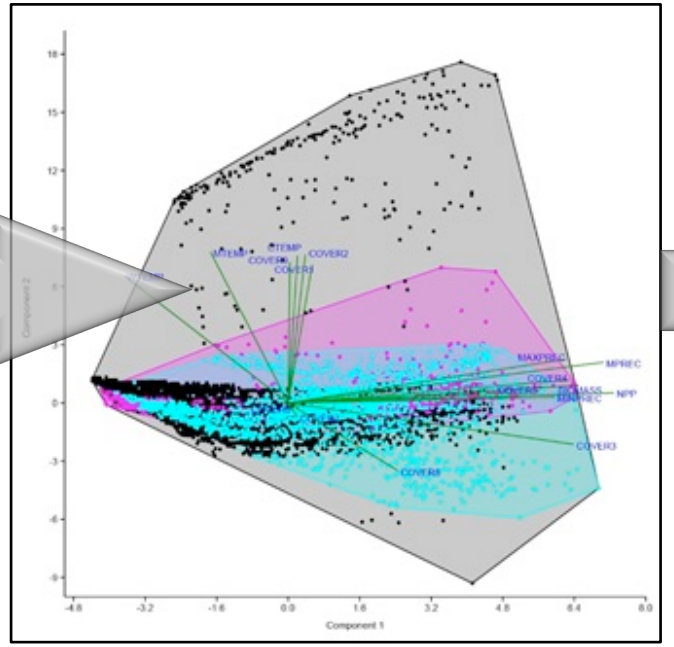
Courtesy Corentin Gibert, PALEVOPRIM Poitiers

The ultimate goal : use climate model outputs + known occurrence of hominids to calculate their ecological niche

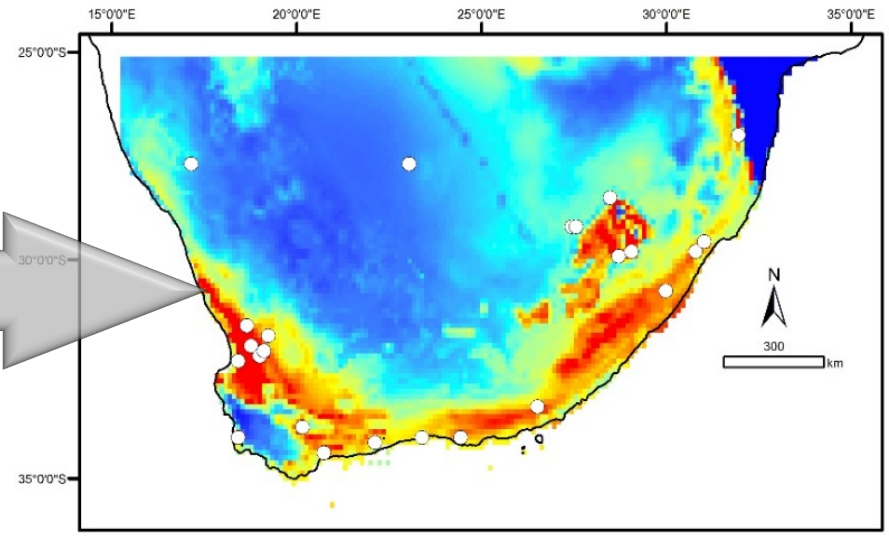
Climate and vegetation variables + occurrence points



Ecological Niche Model (statistic)



Habitat suitability index



Simulations

- 3 coupled simulations with IPSL-CM5A2

2 for the MCO : paleotopography 17 Ma + 700 ppm, or 420 ppm
1 for the MMCT : paleotopography 14 Ma + 420 ppm

- 3 simulations using SSTs for each model LMDZ5A2, LMDZ6 and LMDZ6OR+dynamic vegetation

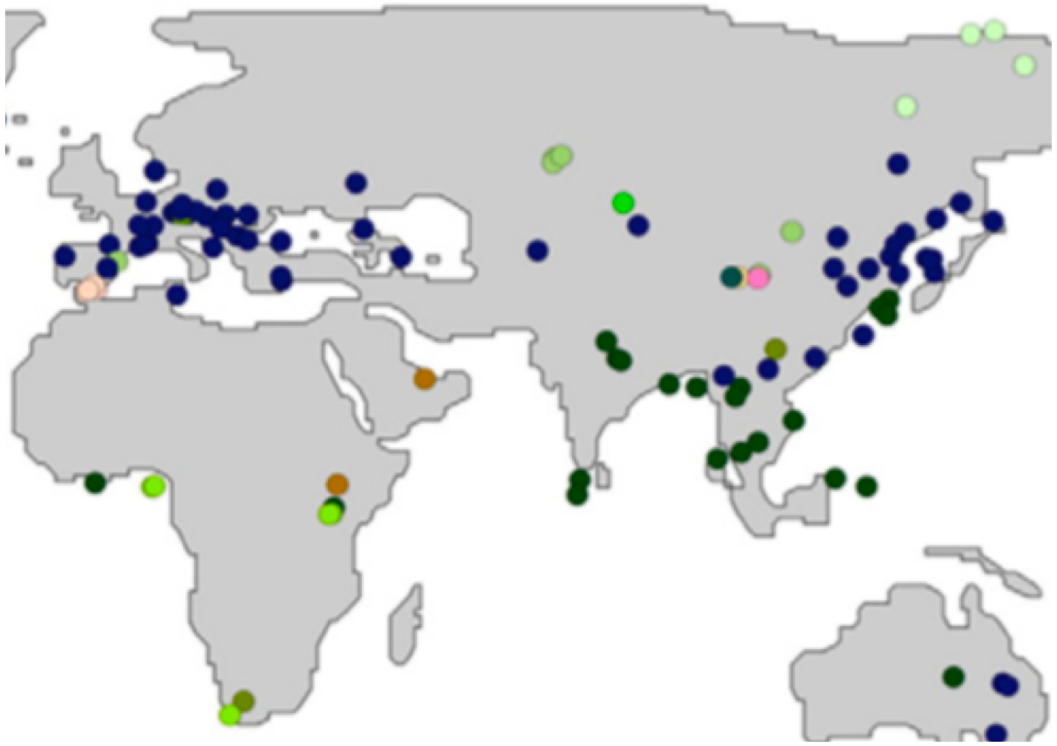
  at resolution 1.4°x0.7° (256x256)

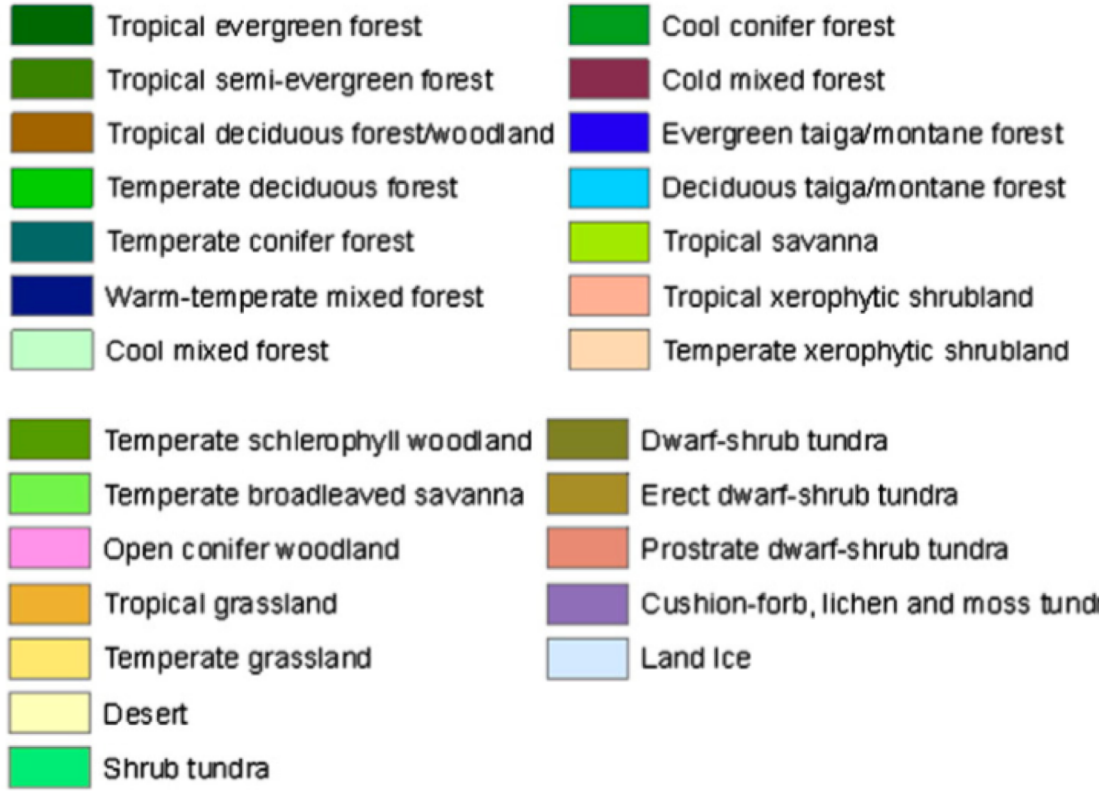
- Each LMDZ output was given to BIOME4 veg model to compare to flora reconstructions (i.e. « the --highly biased-- truth ») using the same nomenclature

- See differences and choose most appropriate for our work

Miocene Climate Optimum (MCO)

Pound et al., ESR, 2012



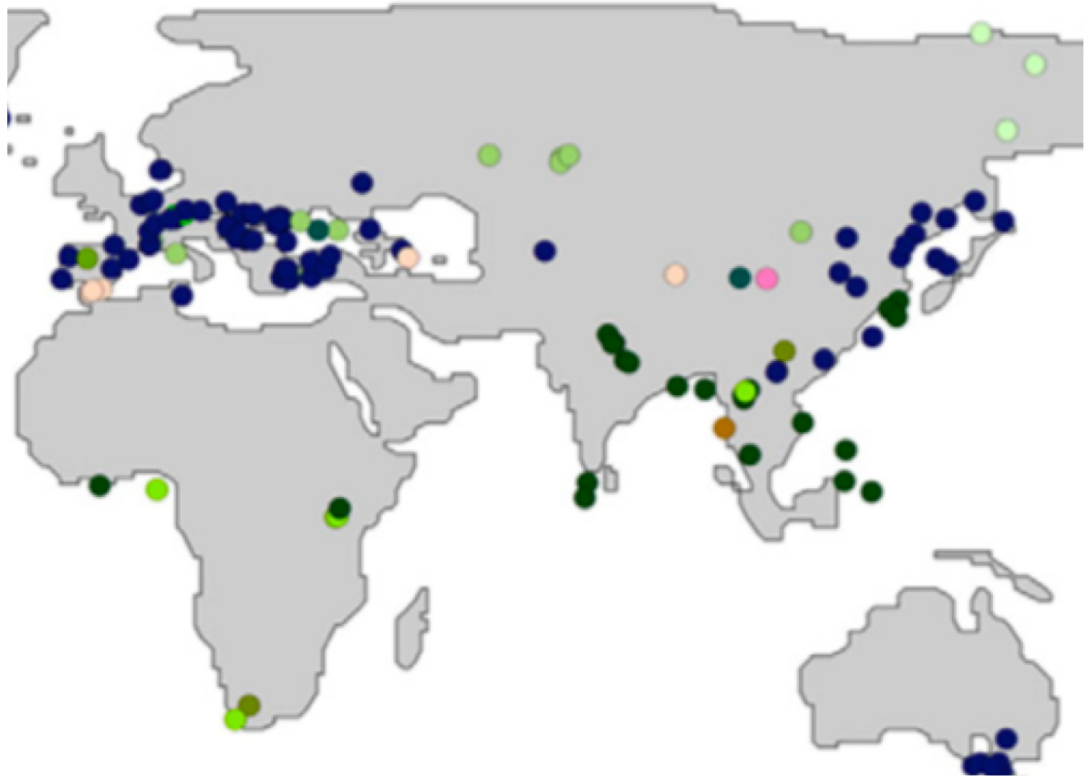


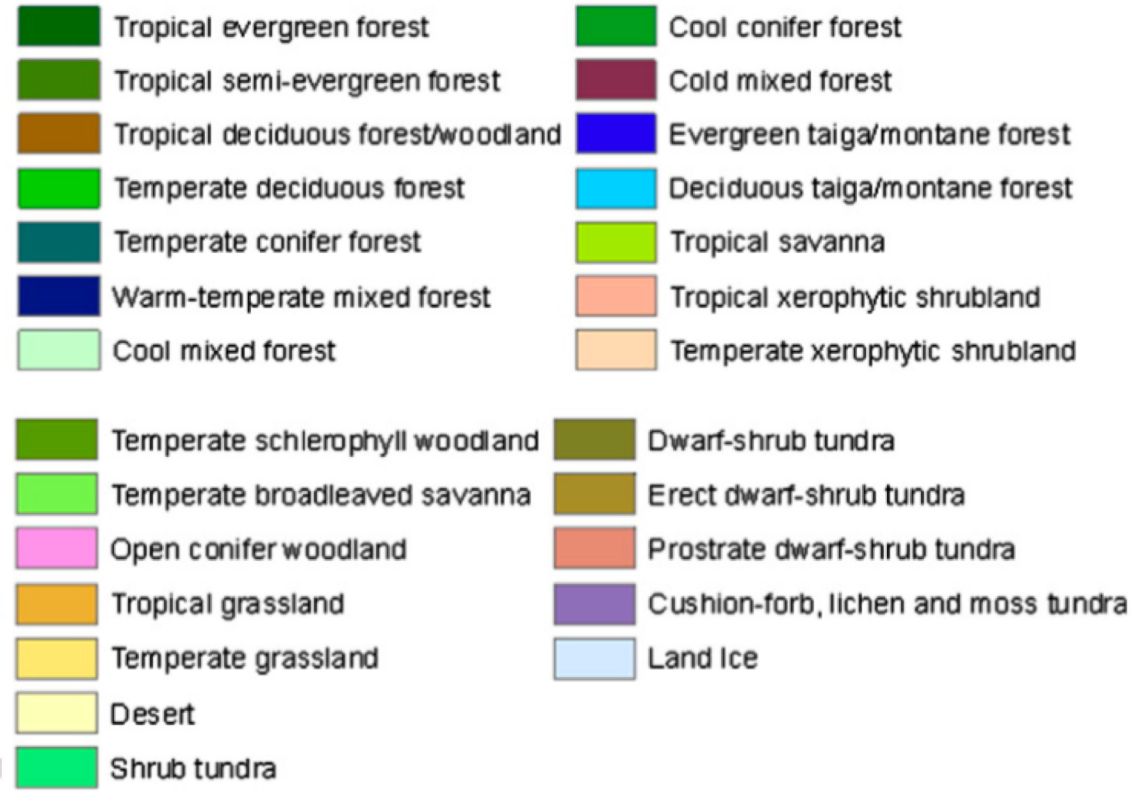
Problems :

- Biomization technique based on author's interpretation i.e. « subjective » → we select mega-biomes rather than biomes.
- Uncertainty on dates mostly >> 2 million years, so many sites appear both on Langhian and Seravallian maps

Middle Miocene Climate Transition (MMCT) ~ Seravallian

Pound et al., ESR, 2012

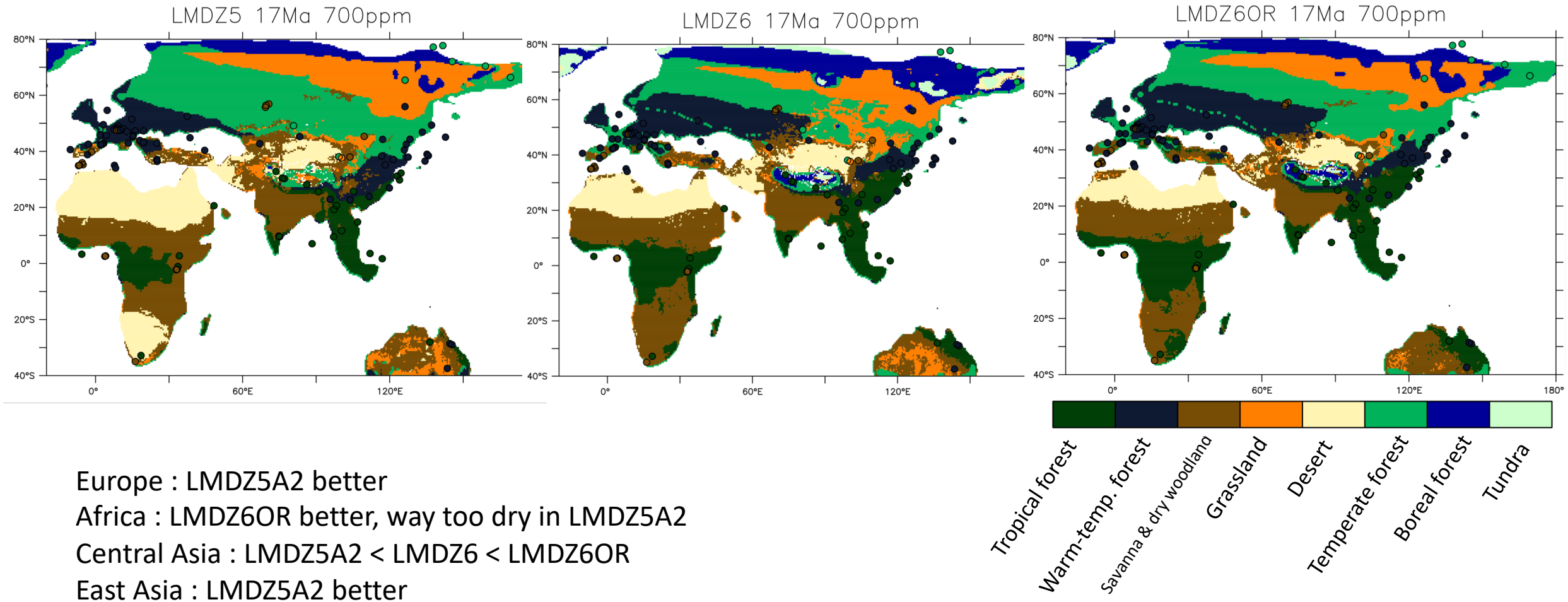




Problems :

- Biomization technique based on author's interpretation i.e. « subjective » → we group biomes into mega-biomes, less likely to be biased.
- Uncertainty on dates mostly >> 2 million years, so many sites appear both on Langhian and Seravallian maps

Model-data comparison for the MCO with 700 ppm

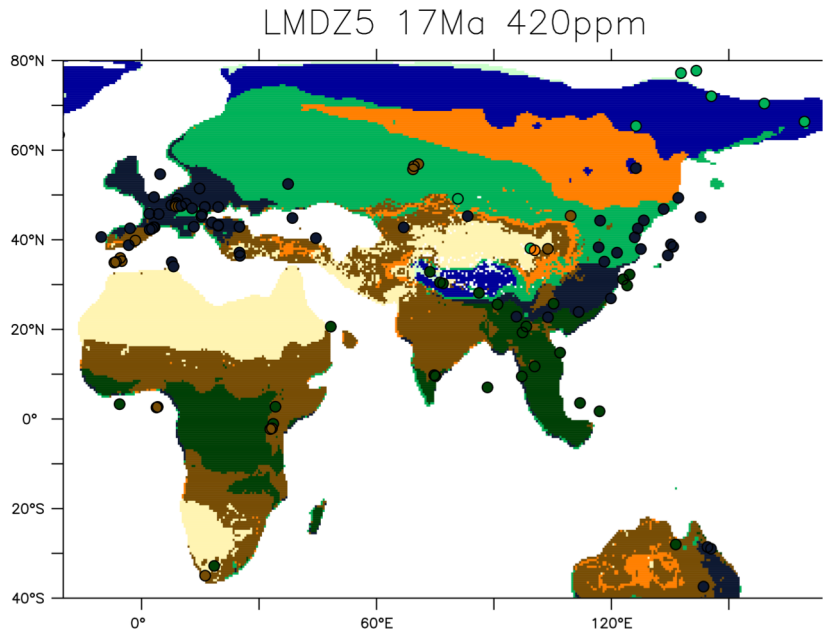


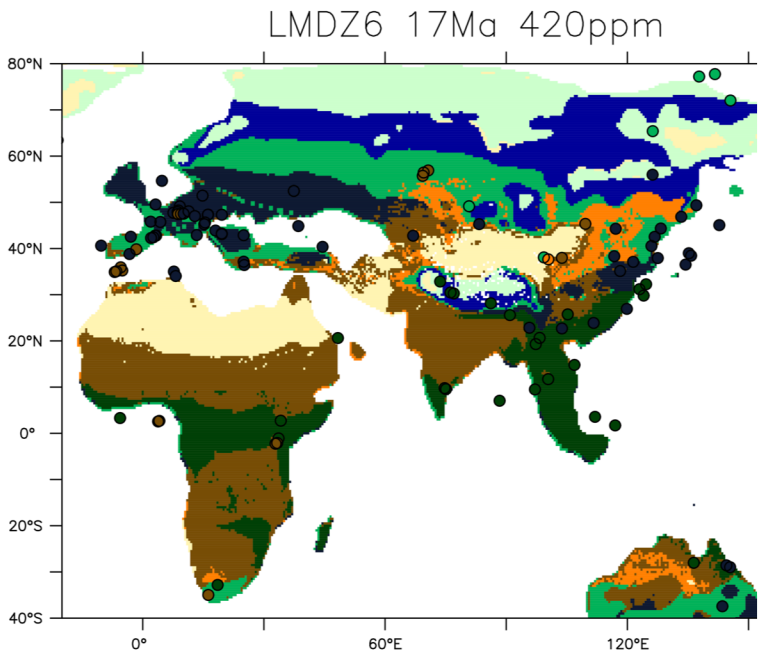
Europe : LMDZ5A2 better
Africa : LMDZ6OR better, way too dry in LMDZ5A2
Central Asia : LMDZ5A2 < LMDZ6 < LMDZ6OR
East Asia : LMDZ5A2 better

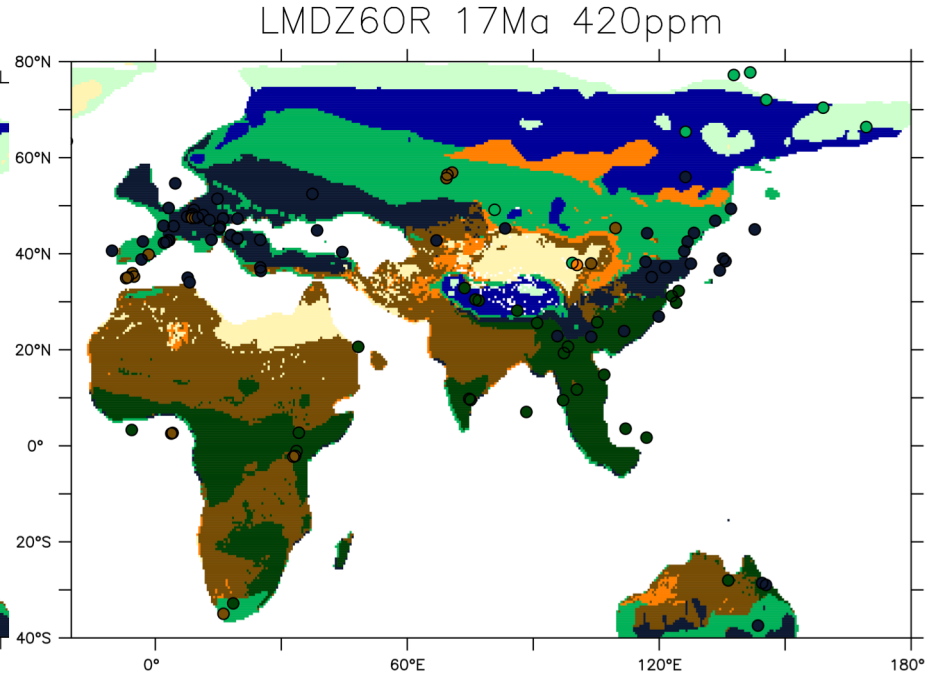
LMDZ6OR (veg dyn) = 49 sur 88 =56%
LMDZ6 = 50 sur 88 = 57%
LMDZ5A2 = 59 sur 88 = 67%
22 far ocean points

← Careful because vegetation data is not evenly distributed and hominind occurrence points neither…

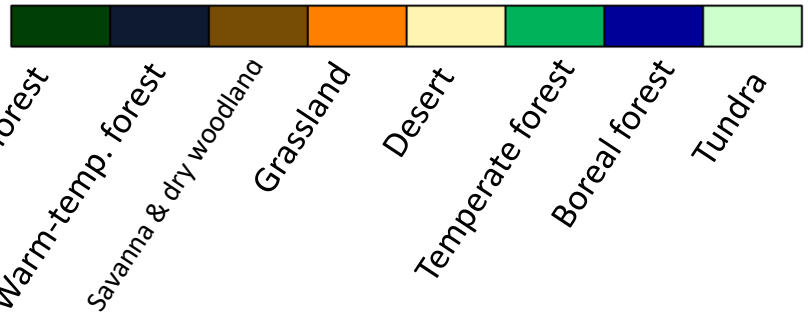
Model-data comparison for the MCO with 420 ppm 1/2







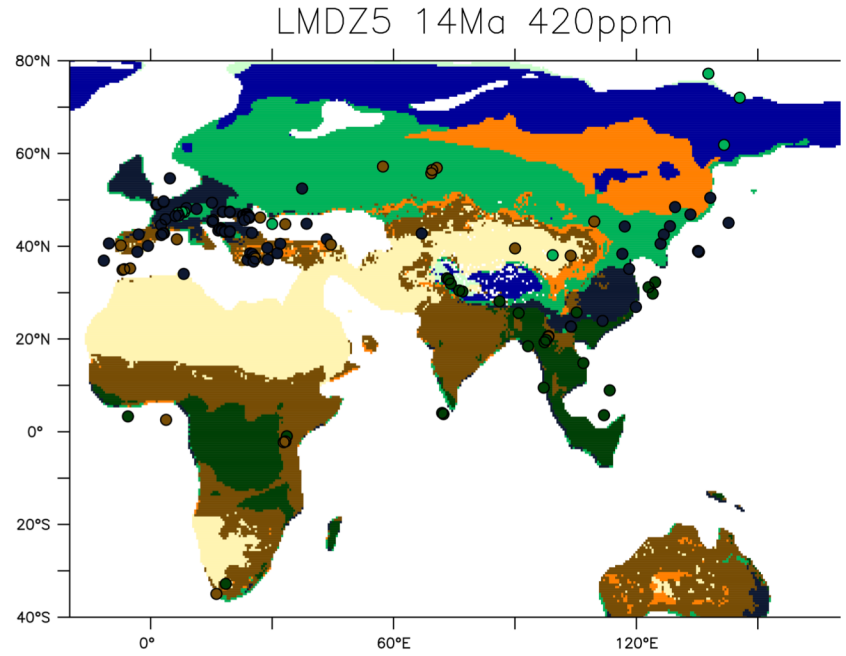
Europe : LMDZ5A2 better
Africa : LMDZ6OR better, way too dry in LMDZ5A2
Central Asia : LMDZ6OR better
East Asia : LMDZ5A2 slightly better

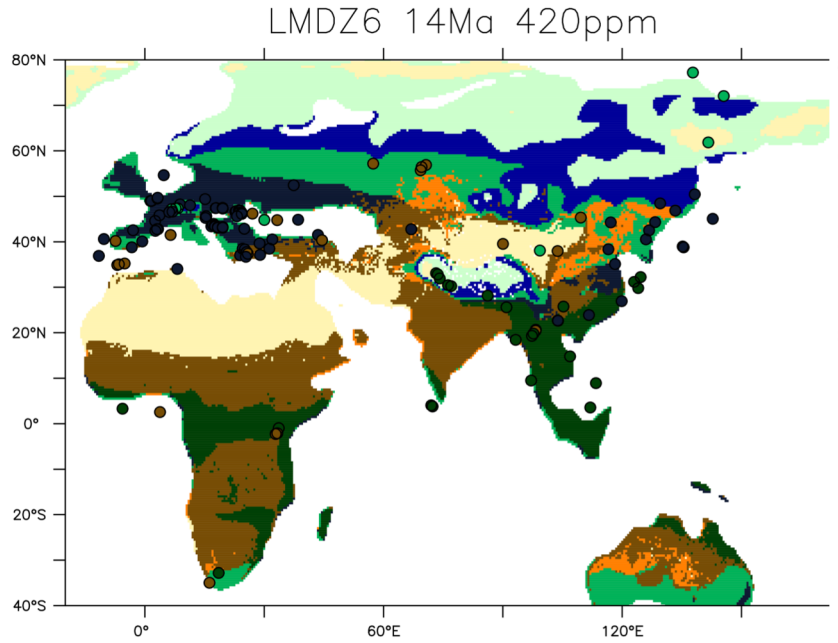


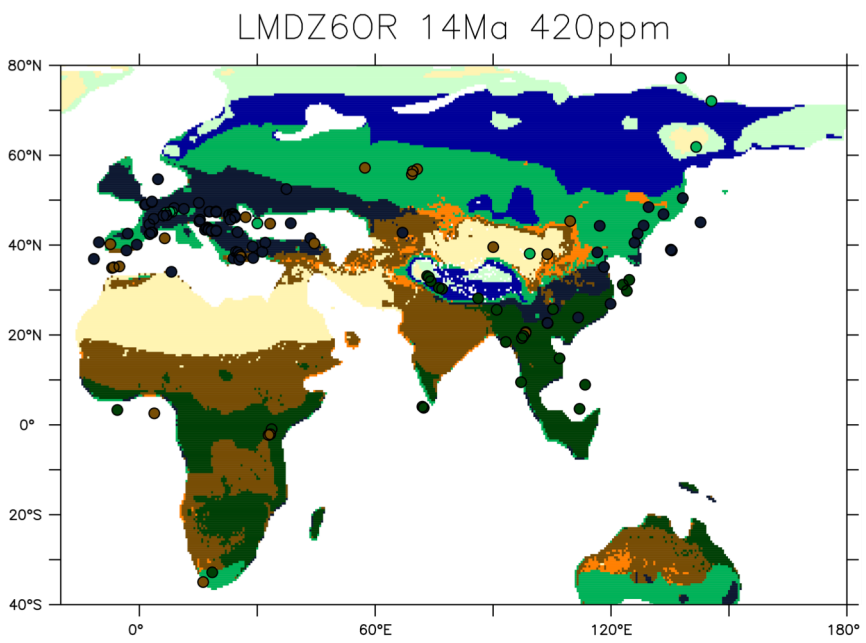
LMDZ6OR (veg dyn) = 58 sur 88 = 66%
LMDZ6 = 52 sur 88 = 59%
LMDZ5A2 = 51 sur 88 = 58%
22 far ocean points

The three models are too cold in Siberia → These result seem to discard the 420 ppm CO2 value for the high latitudes…

Model-data comparison for the MMCT with 420 ppm

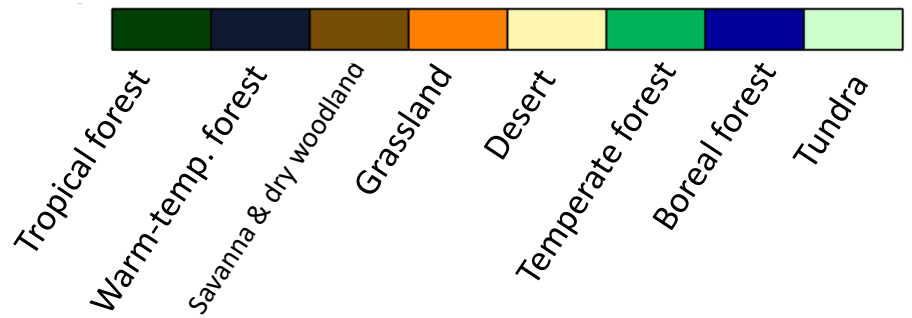




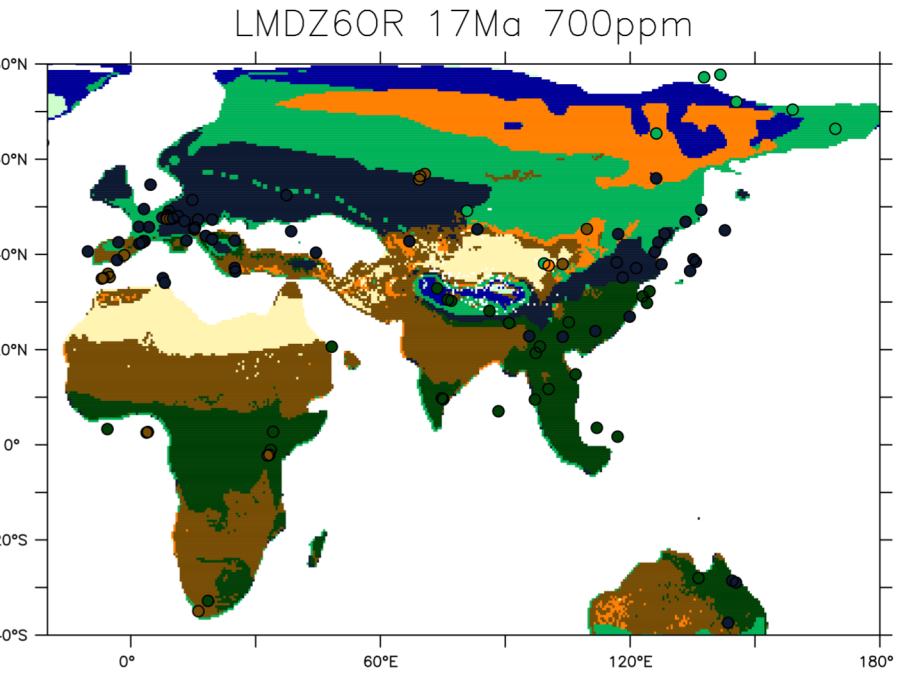


Europe : All models similar
Africa : LMDZ6OR, too dry in LMDZ5A2
Central Asia : LMDZ6OR better
East Asia : LMDZ5A2 better

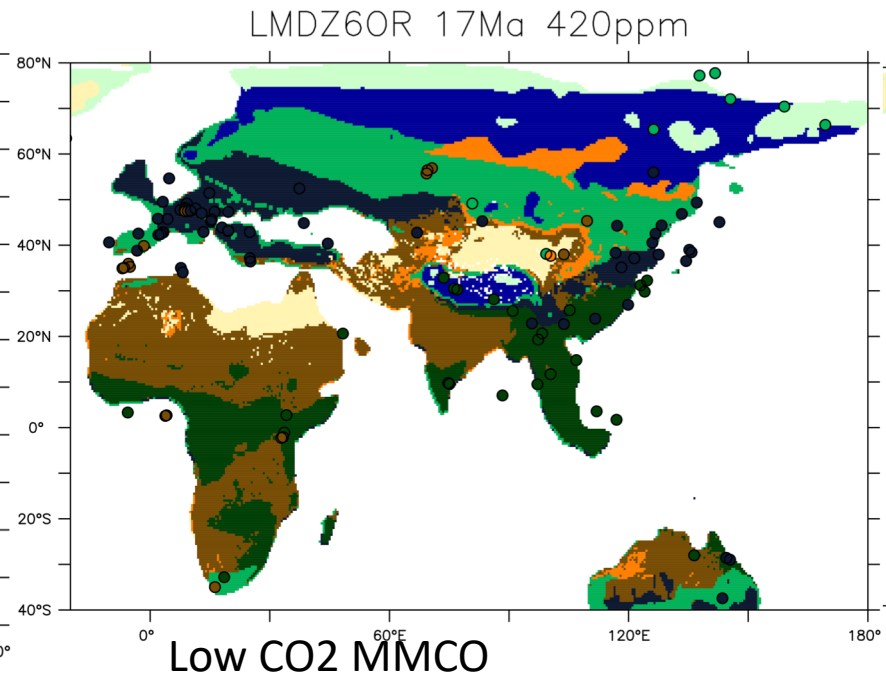
LMDZ6OR (veg dyn) = 82 sur 113 = 73%
LMDZ6 = 77 sur 113 = 68%
LMDZ5A2 = 73 sur 113 = 65%
19 far ocean points



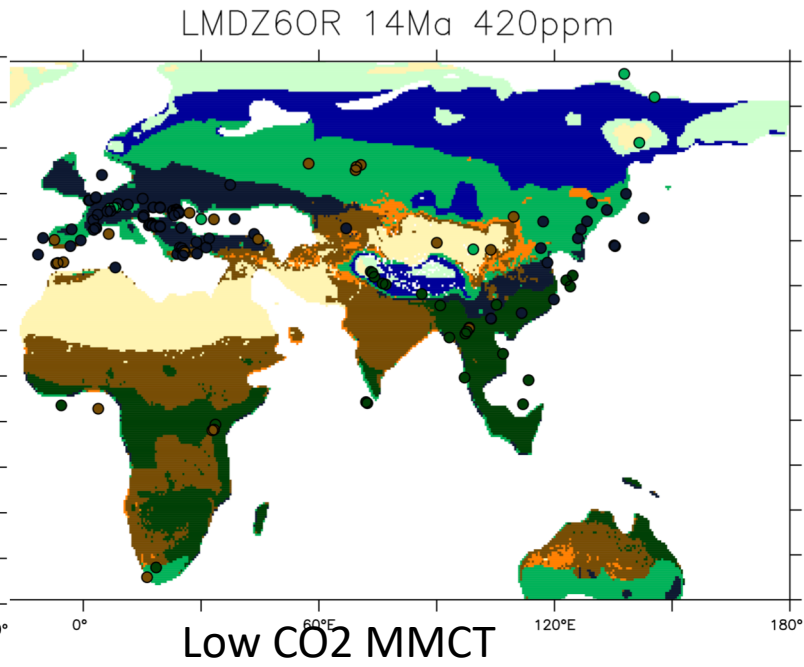
‘Storyline’ of Miocene climate according to LMDZ6OR



High CO2 MMCO



Low CO2 MMCO



Low CO2 MMCT

Choice of LMDZ6OR seems more pertinent given it has the lowest Sahara extent, and hominids must have crossed this barrier to colonize Eurasia

LMDZ6OR has the best score for MCO and MMCT at 420 ppm, not at 700 ppm

Take-home messages

- The extent of Sahara is bigger in LMDZ5A2 than LMDZ6 than LMDZ6OR, it is also wider at 700 ppm than at 420 ppm.

  → real signal or problem in the model ?

- The bias towards wet Sahara in LMDZ6 and LMDZ6OR can be seen as an advantage for Miocene simulations (as well as Pliocene and mid-Holocene)

- Need to reconstruct flora at hominid sites to better evaluate the model