Role of ECVs in climate-carbon feedback assessment

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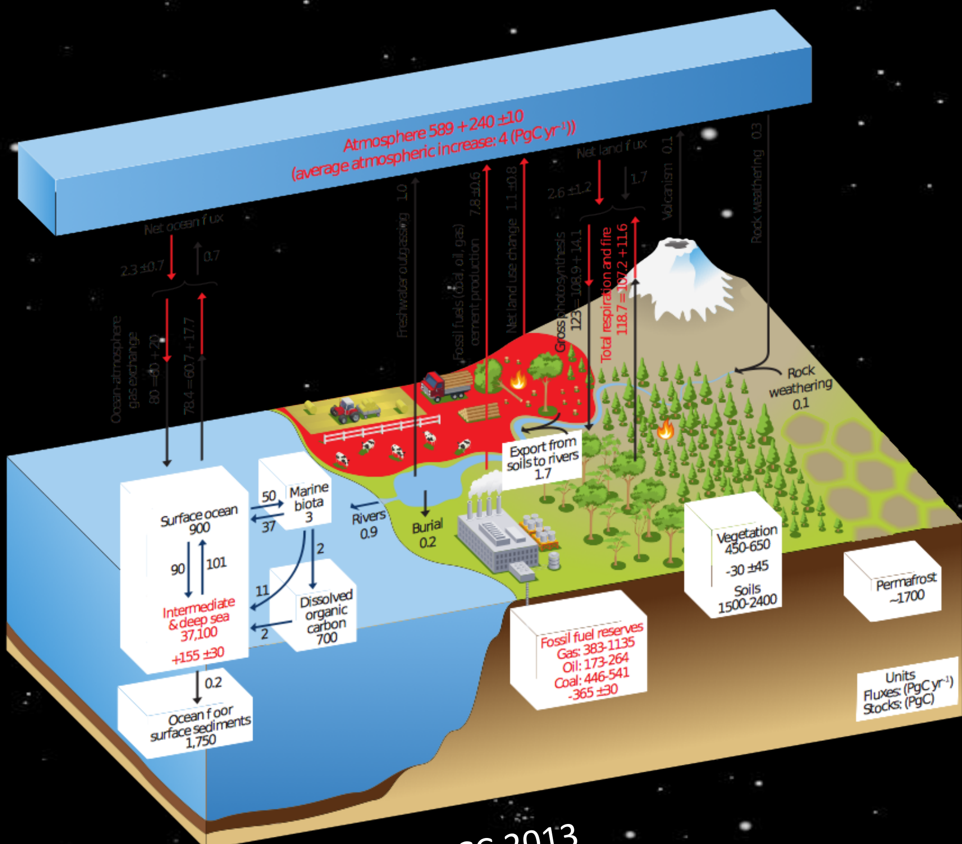
1. Climate-Carbon Feedback
2. ECVs
3. First tests with CCI - soil moisture
4. Conclusions

Climate-carbon Feedback



AR5 –Chap6. IPCC,2013

55 % of CO_2 emissions are absorbed by sinks :

29 % by land

26 % by oceans

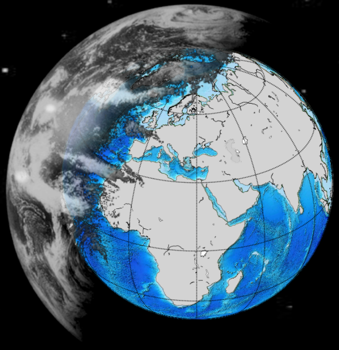
=> limit global warming

BUT sinks efficiencies vary with changes in environment (temperature)

CARBON-CLIMATE FEEDBACK

Example : IPSL-CM5A-LR

+



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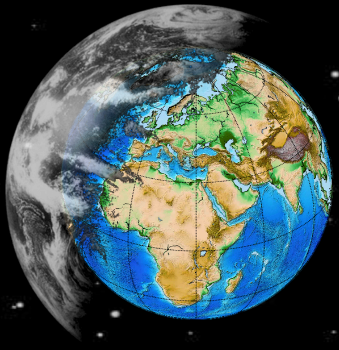
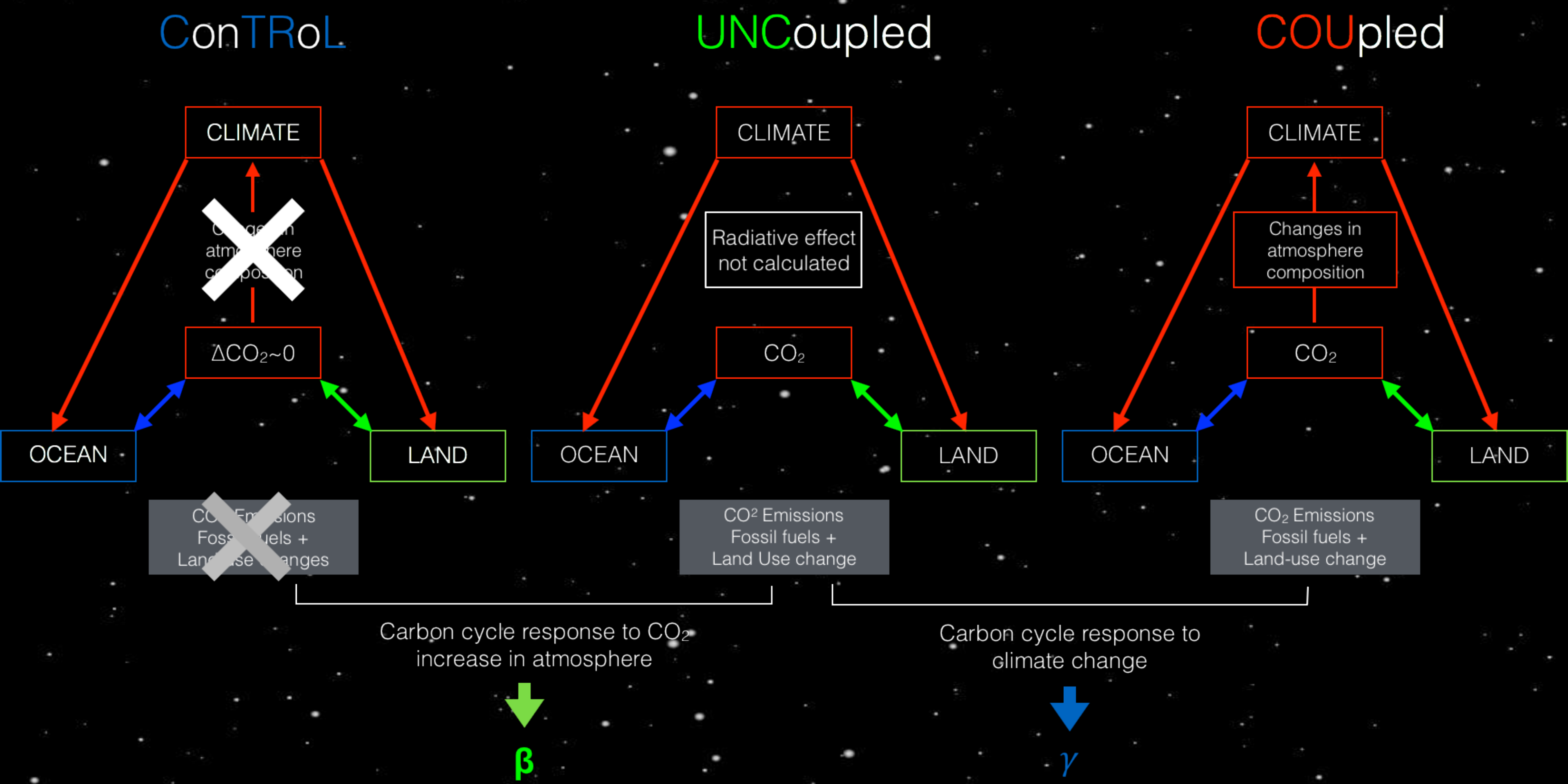


LMDZ
Atmospheric Model
Hourdin et al., 2007

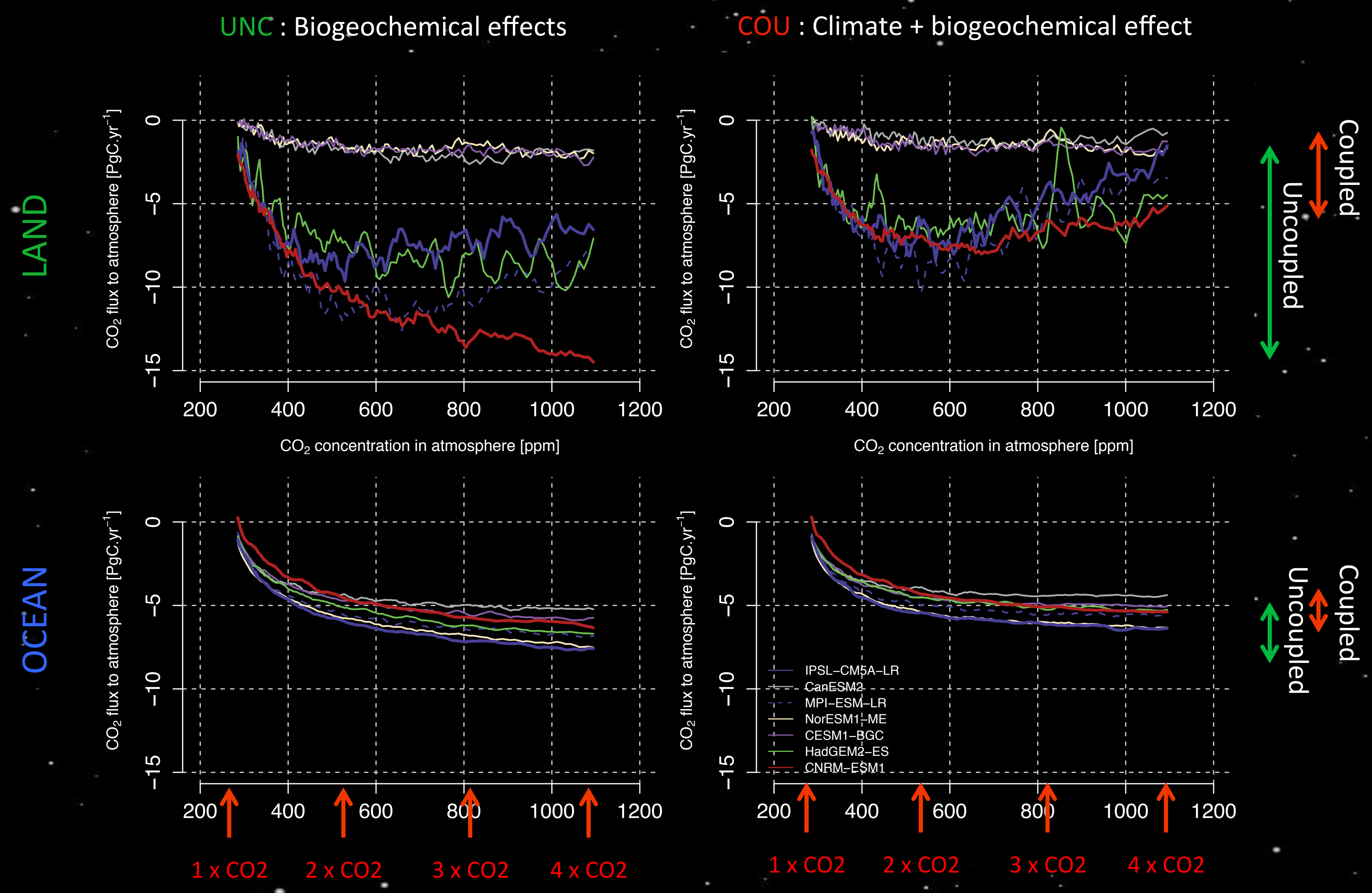
Nemo - Pisces
Ocean Circulation and biogeochemical Models
Madec et al., 2002 – Aumont and Bopp, 2006

ORCHIDEE
Land Surface Model
Krinner et al, 2005

Identification and understanding of feedbacks independently to each other during different period (past, present, futur)


ConTRoL
UNCoupled
COUpled
CLIMATE
CLIMATE
CLIMATE
Changes in atmosphere composition
Radiative effect not calculated
Changes in atmosphere composition
ΔCO₂~0
CO₂
CO₂
OCEAN
LAND
OCEAN
LAND
OCEAN
LAND
CO₂ Emissions Fossil fuels + Land use changes
CO² Emissions Fossil fuels + Land Use change
CO₂ Emissions Fossil fuels + Land-use change
Carbon cycle response to CO₂ increase in atmosphere
Carbon cycle response to climate change
β
γ

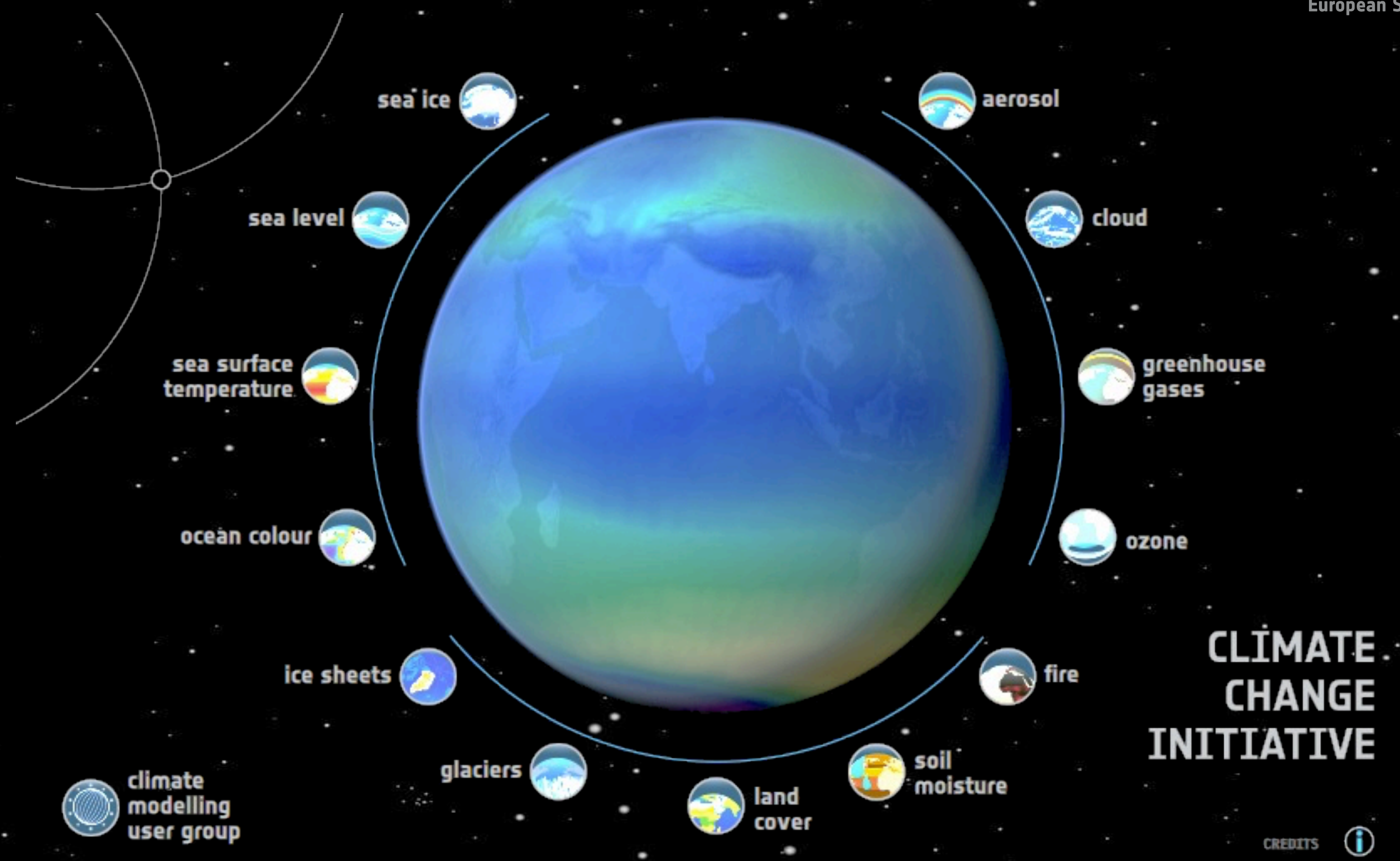
Responses of land and ocean sinks to atmospheric carbon emissions



Importante uncertainties related to the land carbon cycle modelling (e.g. : IPCC, 2013 ; Friedlingstein et al., 2014) => Emerging constraint (e.g. Hall and Qu, 2006 and Wenzel et al, 2014)

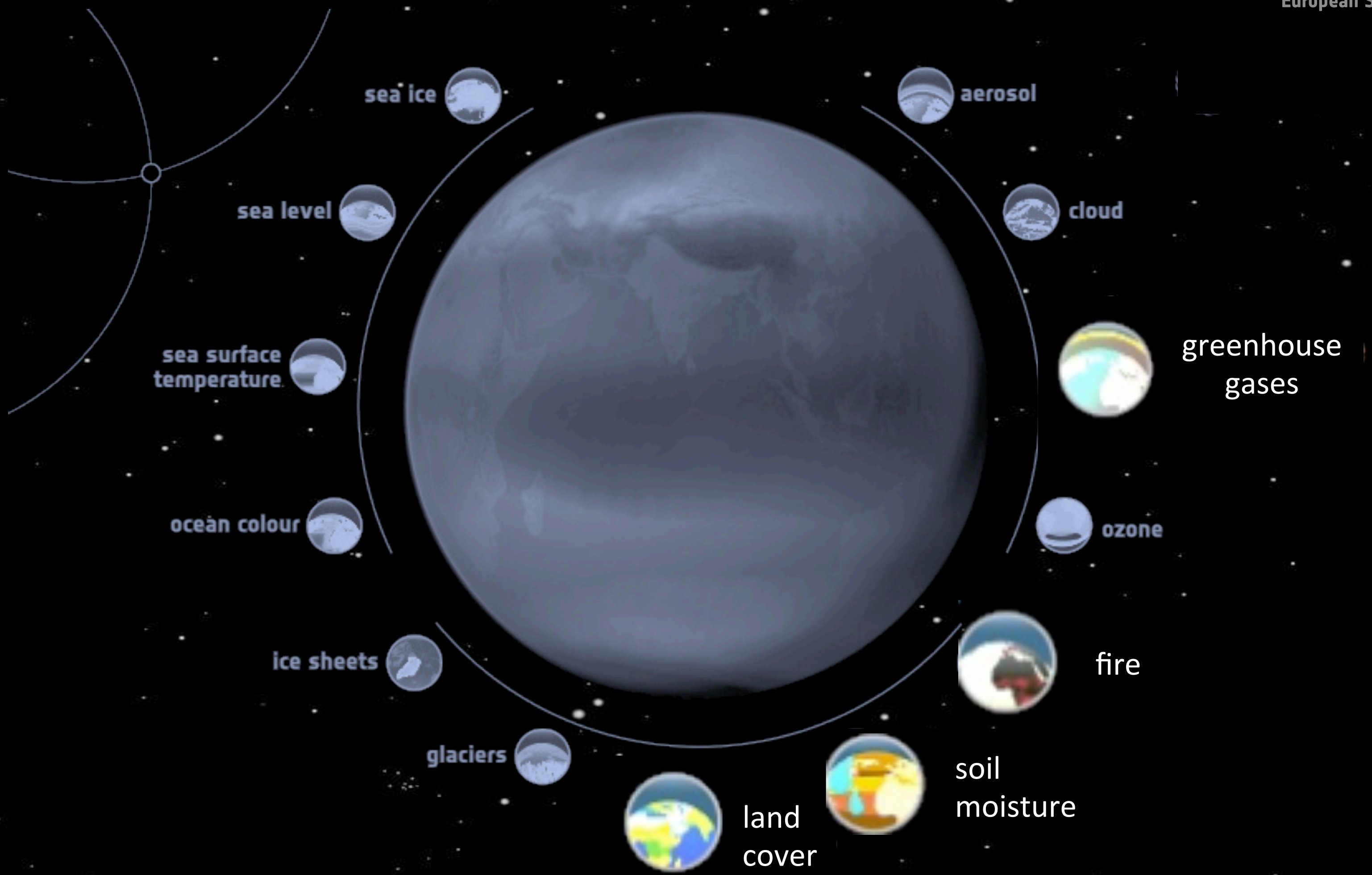
50 ECVs defined by GCOS / 13 provided by CCI

esa
European Space Agency

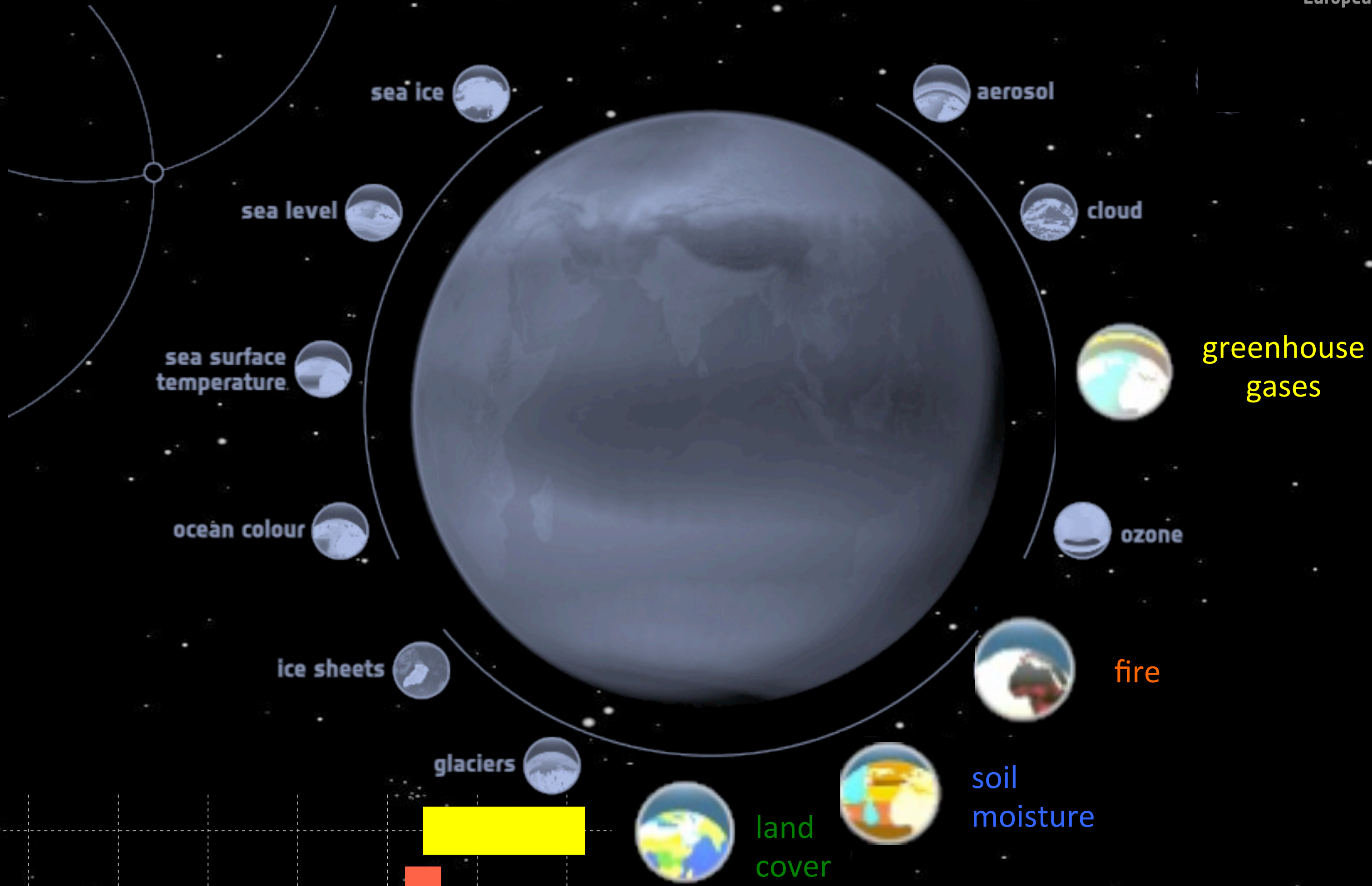


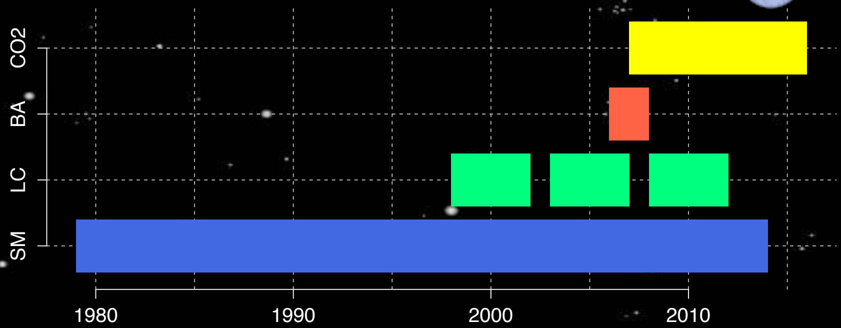
Essential Climate Variables

50 ECVs defined by GCOS / 13 provided by CCI

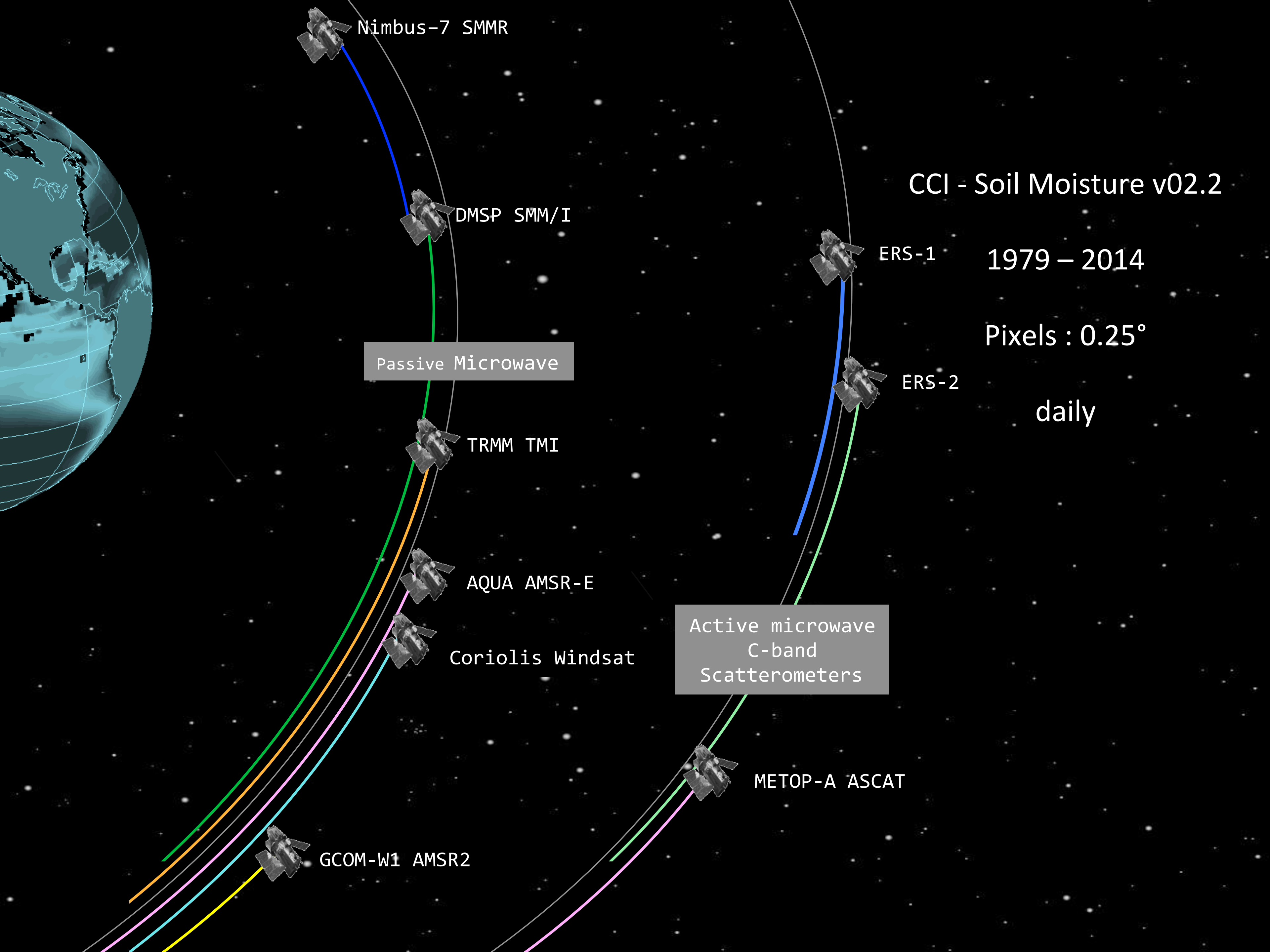


50 ECVs defined by GCOS / 13 provided by CCI



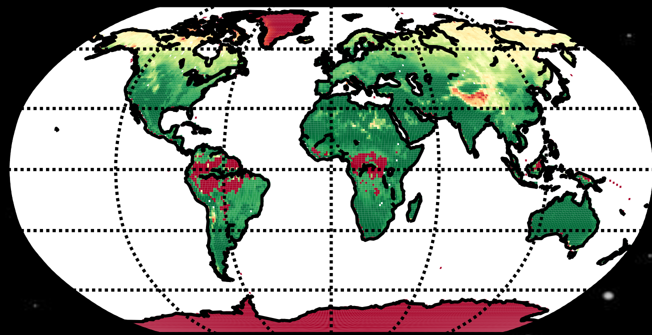


CCI Soil moisture presents the longest time series

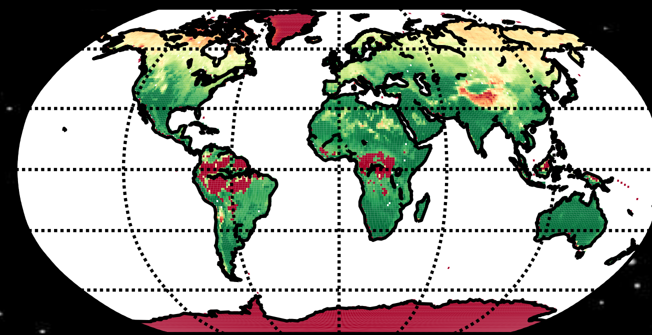


Nimbus-7 SMMR
DMSP SMM/I
Passive Microwave
TRMM TMI
AQUA AMSR-E
Coriolis Windsat
GCOM-W1 AMSR2
ERS-1
ERS-2
Active microwave
C-band
Scatterometers
METOP-A ASCAT
CCI - Soil Moisture v02.2
1979 – 2014
Pixels : 0.25°
daily

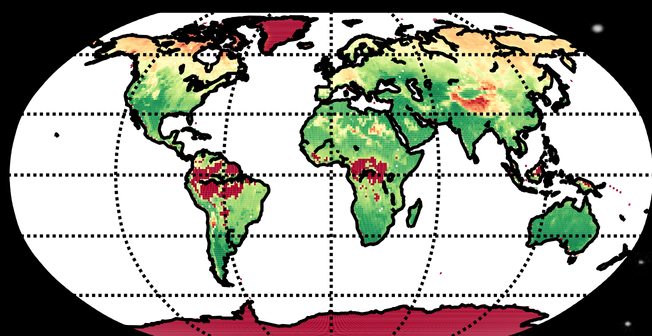
1 obs min = > 62 %



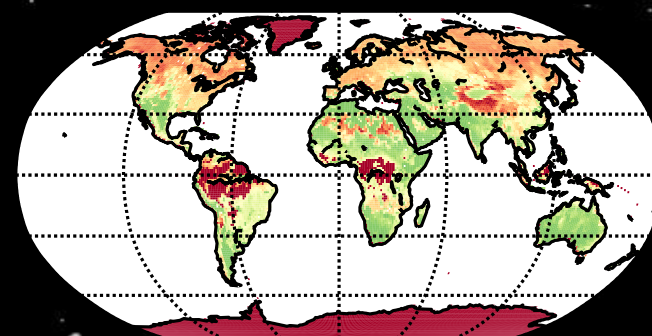
3 obs min = > 57 %

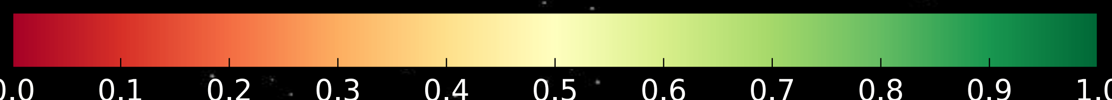


5 obs min = > 49 %

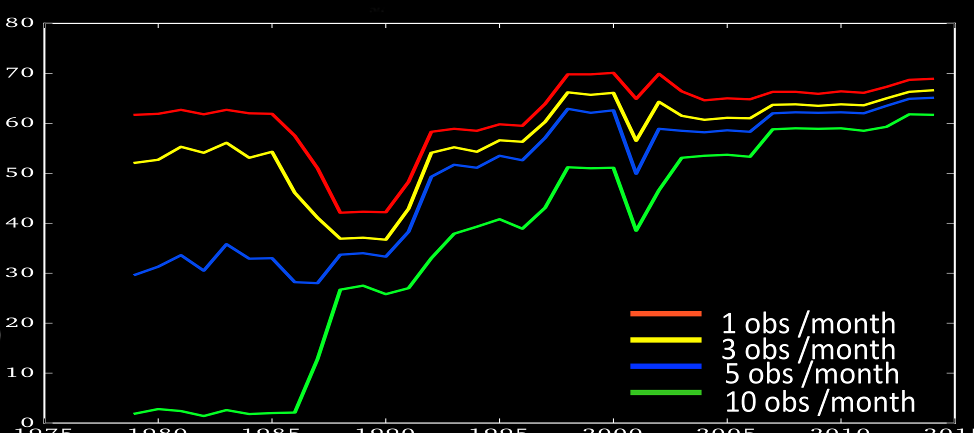


10 obs min = > 36 %





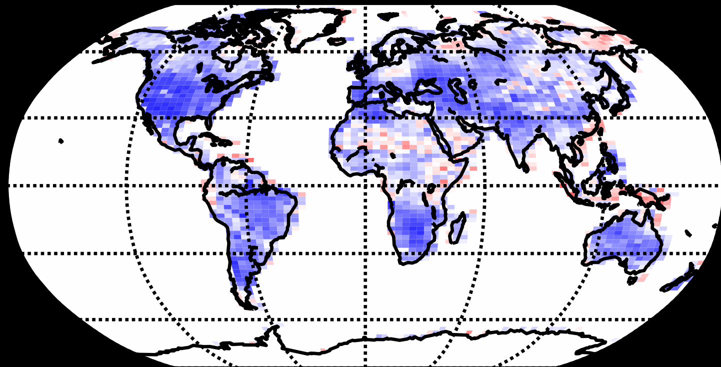
Spatial coverage depending on the temporal aggregation.



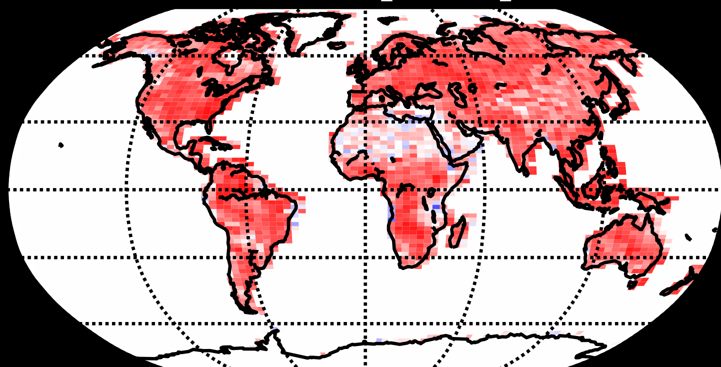
In agreement with Loew et al., 2013

Correlations between SM and climate variables in IPSL model

Soil moisture-temperature R = -0.23



Soil moisture-precipitation R = 0.49



IPSL-CM5A-LR (amip run – 1980-2009)

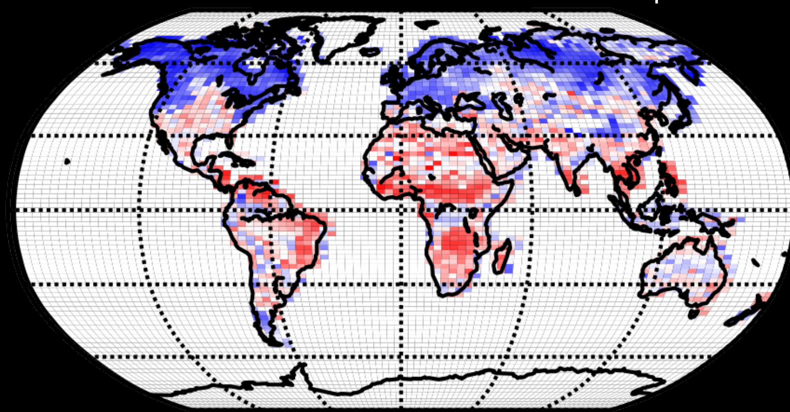
The hottest, the driest
With high seasonal contrasts => especially true during spring in the northern hemisphere

Positive correlation between precipitation and soil moisture

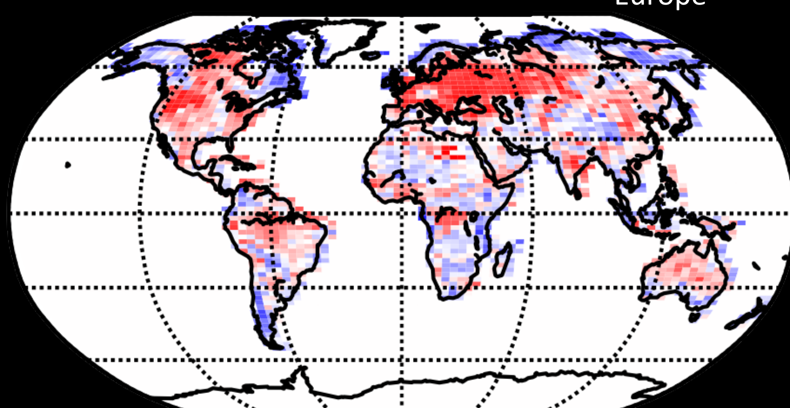
In models, soil moisture sums up climate information about temperature and precipitaiton

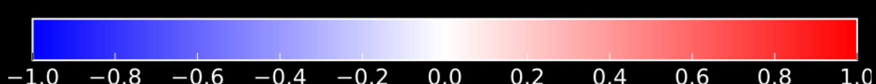
Correlations between GPP and SM in IPSL model

Spring $R_{Europe} = -0.36$



Summer $R_{Europe} = 0.34$

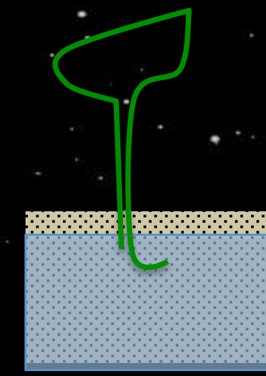


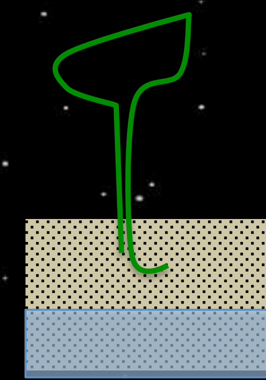


amip simulation – mean over 1980-2009

Europe and North America highlight
DIFFERENT VEGETATION MECHANISMS

Photosynthesis
Pumps water



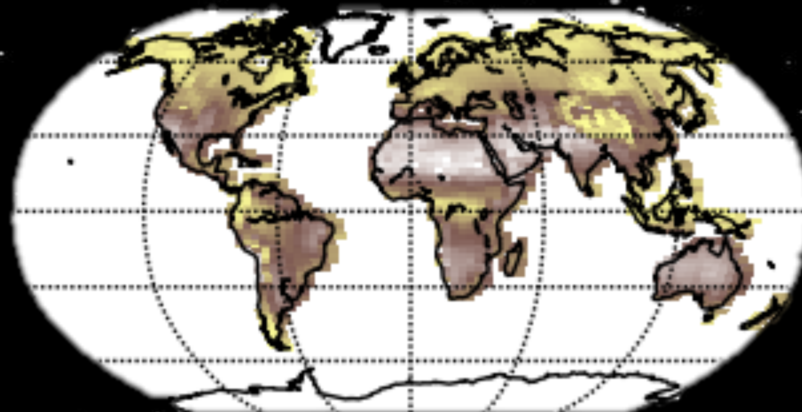


Water stress =>
No Photosynthesis, occurs when soil moisture increases.

Coupling between vegetation and soil moisture _ can this relation be observed?

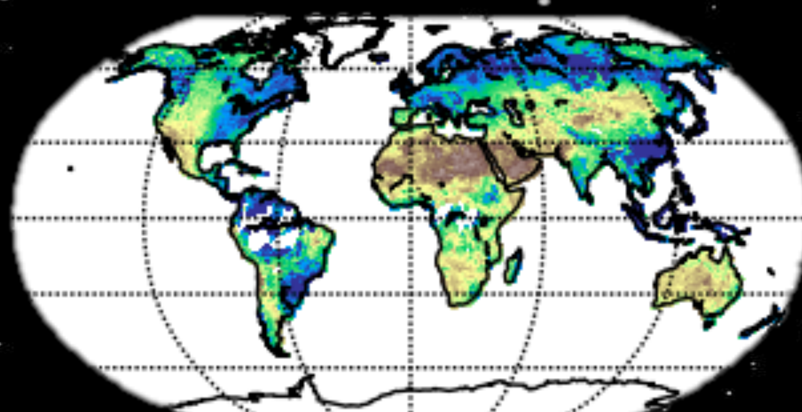
Comparison of soil moisture in IPSL-CM5A-LR and CCI-Soil Moisture

IPSL-CM5A-LR – amip simulation



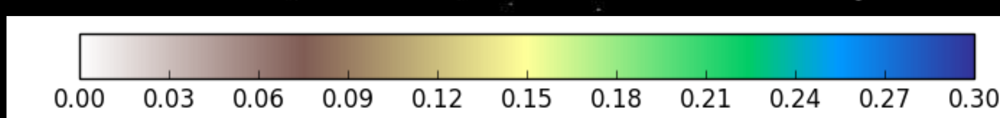
SM global = $0.10\ m^3/m^3$

CCI – Soil Moisture



SM global = $0.21\ m^3/m^3$

Mean over 1980-2009



m^3/m^3

The model is a lot **drier** than the observations

BUT

Soil moisture is not given at the same scale : 10cm vs 2-5cm

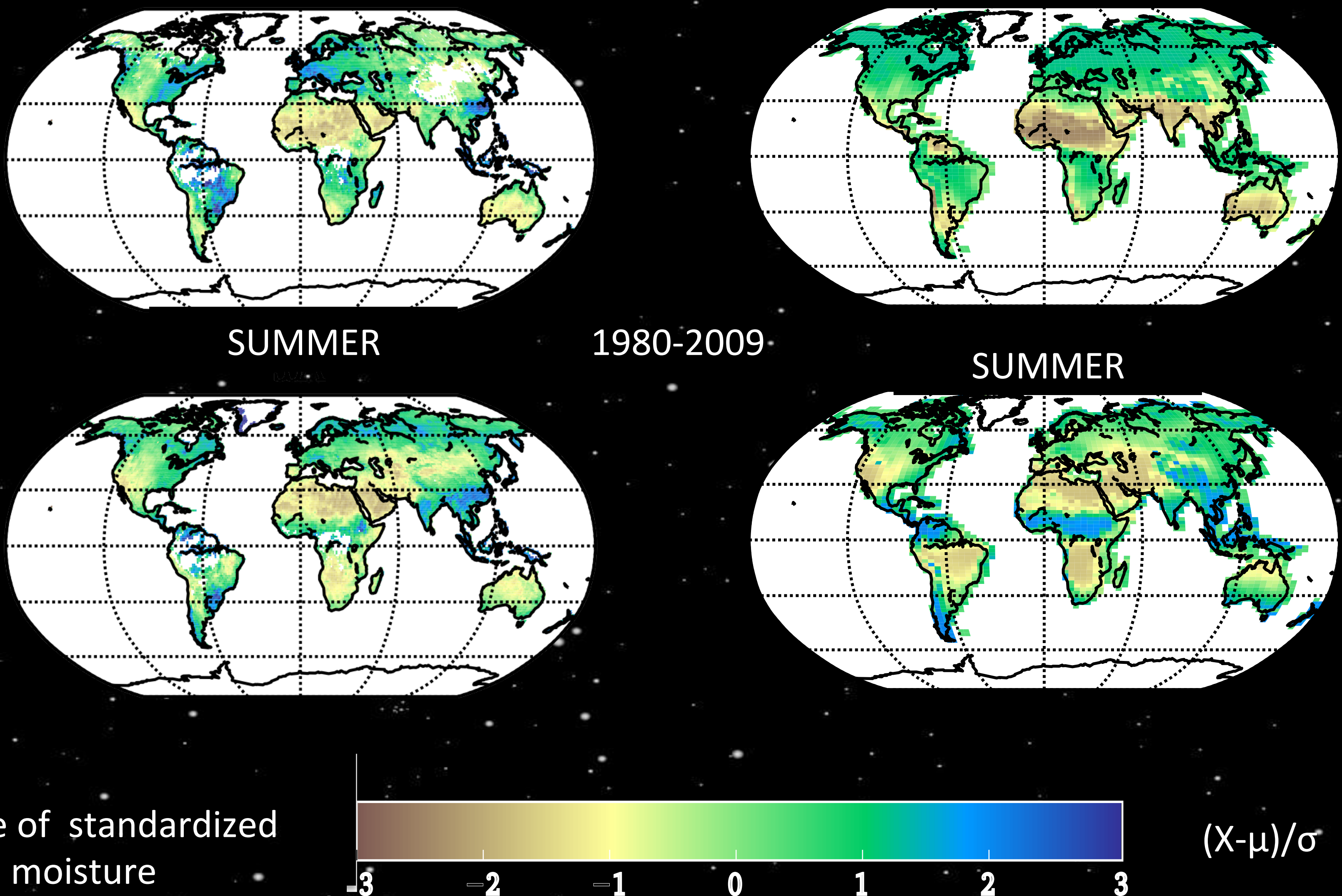
Differences in mean water content but also in dynamics

Need for normalization! (Reichle et *al*., 2004)

OBSERVATIONS

AMIP IPSL SIMULATION

WINTER

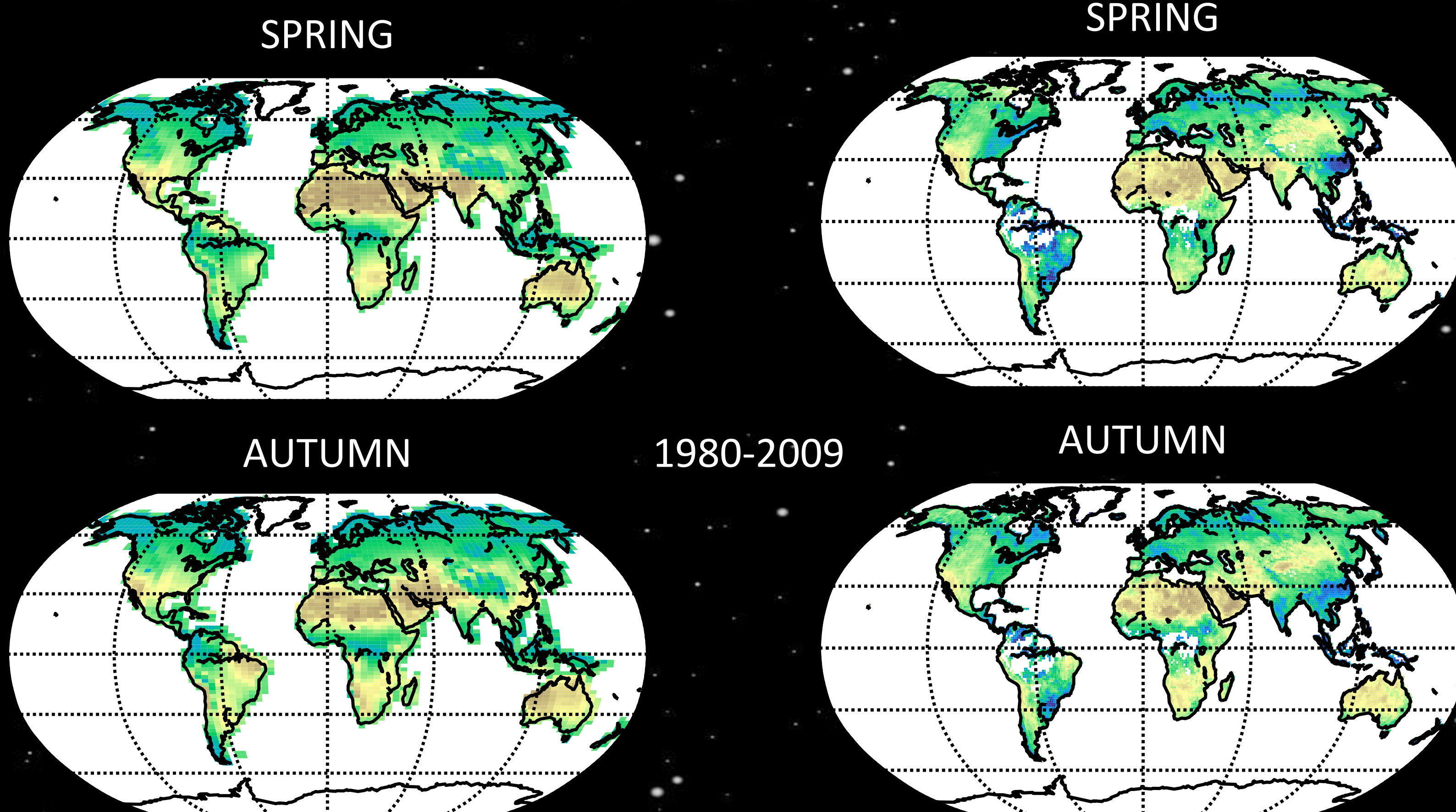


Use of standardized soil moisture

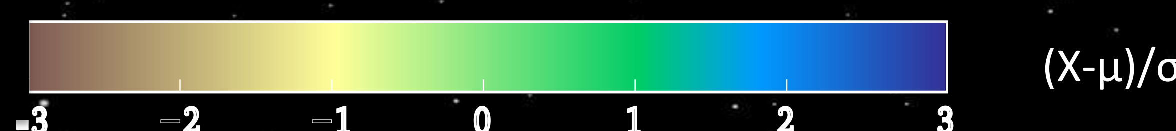
$(X-\mu)/\sigma$

OBSERVATIONS

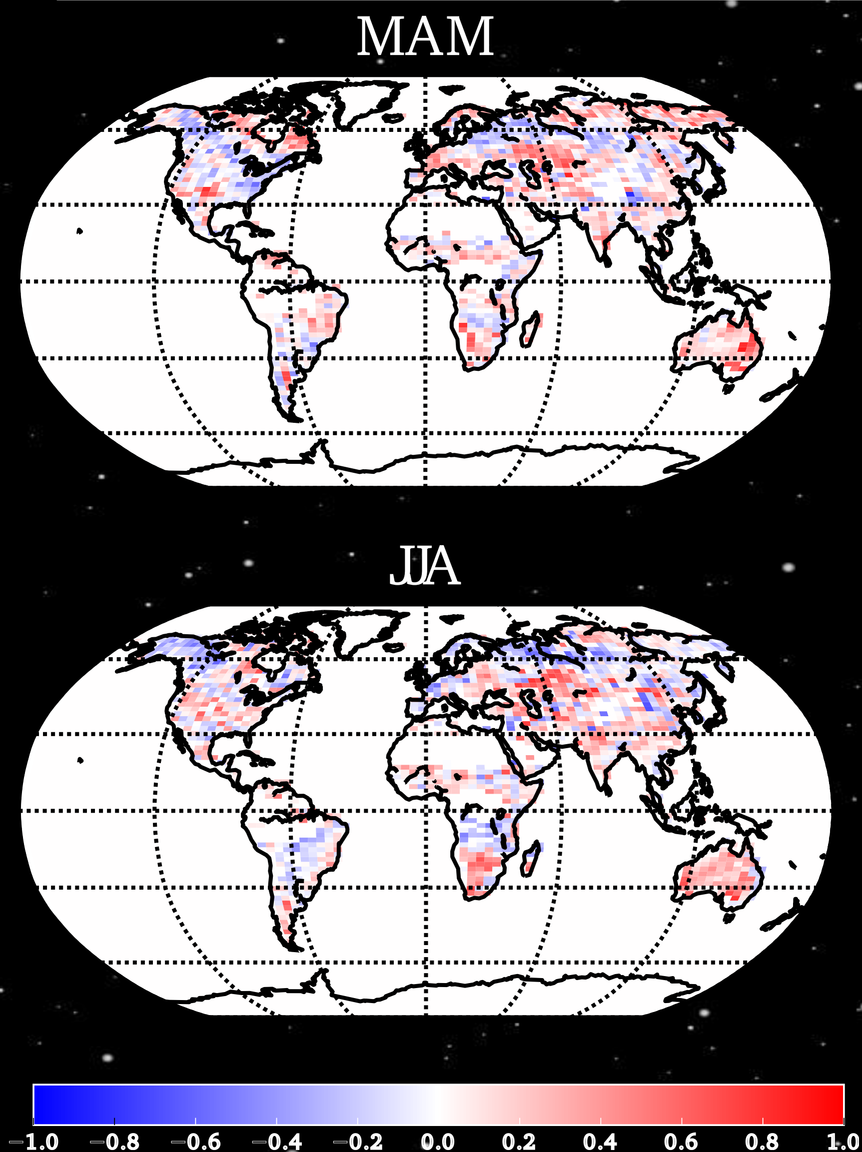
AMIP IPSL SIMULATION



Use of standardized soil moisture



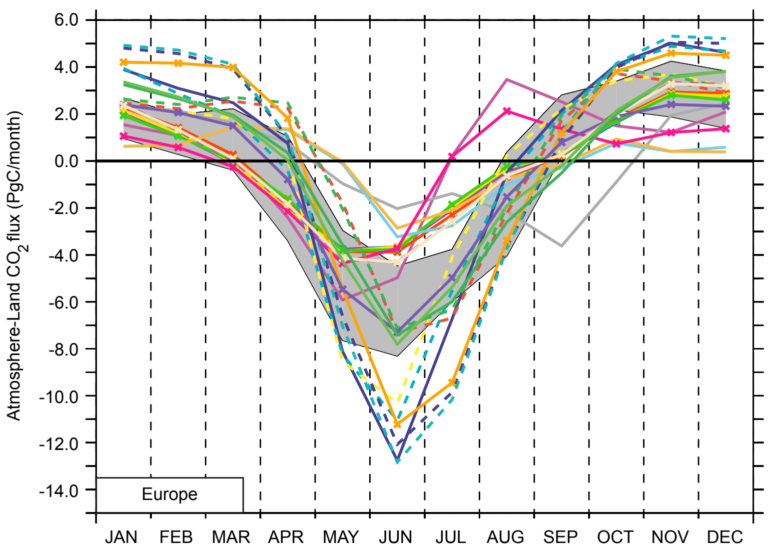
Comparison with observed correlations between GPP (Jung et al. 2014) and CCI -Soil Moisture



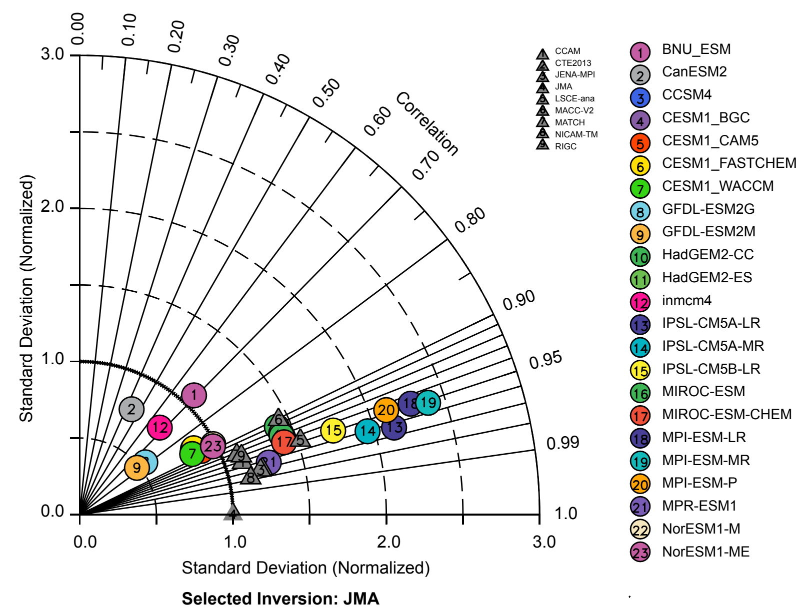
No significant correlations in the observations :

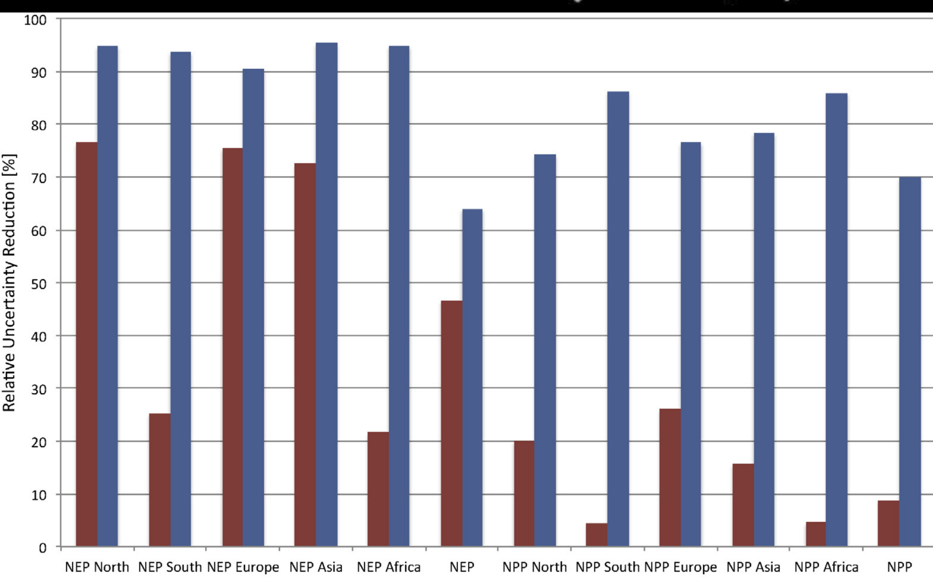
- Are there other processes not taken into account in the IPSL model?
- Is data coverage not sufficient during these seasons?

The added value of Soil Moisture data



NBP
CMIP5 models
(1979-2005)





- The relative uncertainty reduction for NEP for the ‘CO2-SMOS’ assimilation experiment is high for all six regions and also for all regions higher than for the ‘CO2’ assimilation experiment. The SMOS soil moisture observations act here as an additional constraint on the net carbon fluxes even in regions which are not sampled by the CO2 observations.

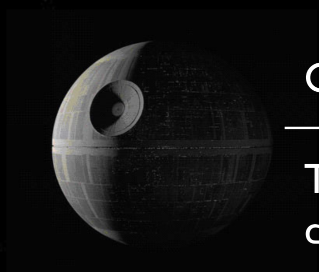
Uncertainty reduction relative to prior for NEP and NPP over six regions for experiments ‘CO2’ (red) and ‘CO2-SMOS’ (blue). Scholze et al., 2016.

Conclusions

Soil moisture data

- High potential for soil moisture data to constrain carbon cycle
⇒ tight coupling between vegetation and climate.

- Temporal and spatial aggregation must be careful done.



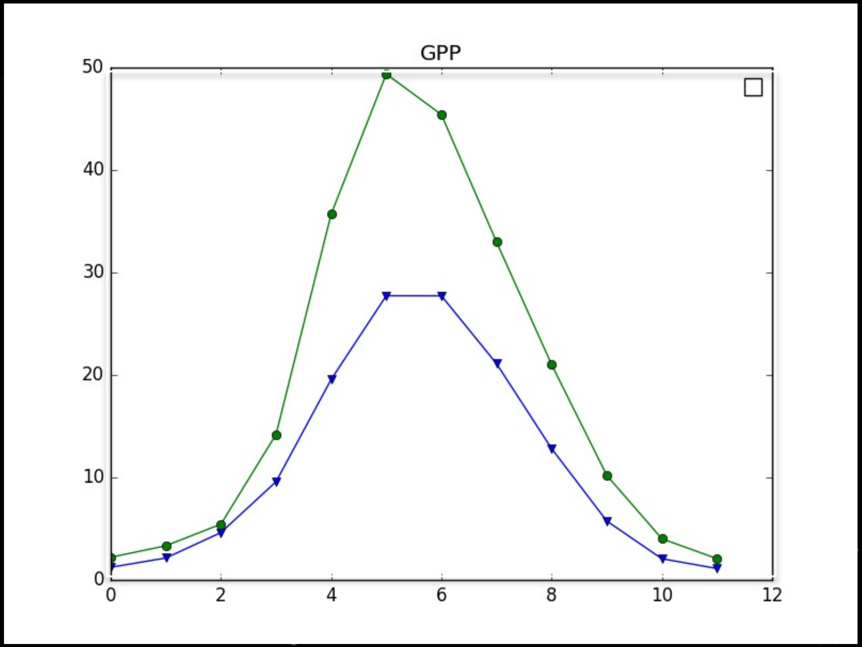
Comparison with the IPSL model

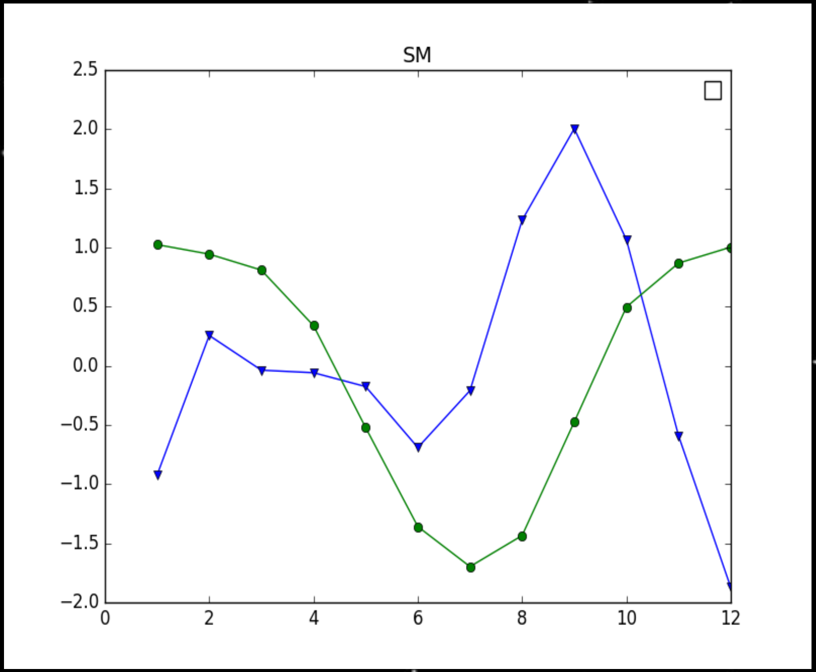
The IPSL model is a lot drier than the observations but comparison can be done with normalized data.

Performances should be improved in CMIP6 because of a new hydrological scheme in the soil.

Perspectives

- Identify a relationship between model performances and sensitivity of the carbon sinks to soil moisture
- Use of CO2 CCI as cross-evaluation and additional constraint
- ….





Seasonal Cycle of GPP and Soil Moisture
in
Europe