Spread induced by initial perturbations in decadal forecasts: Where are the major sources of uncertainties?

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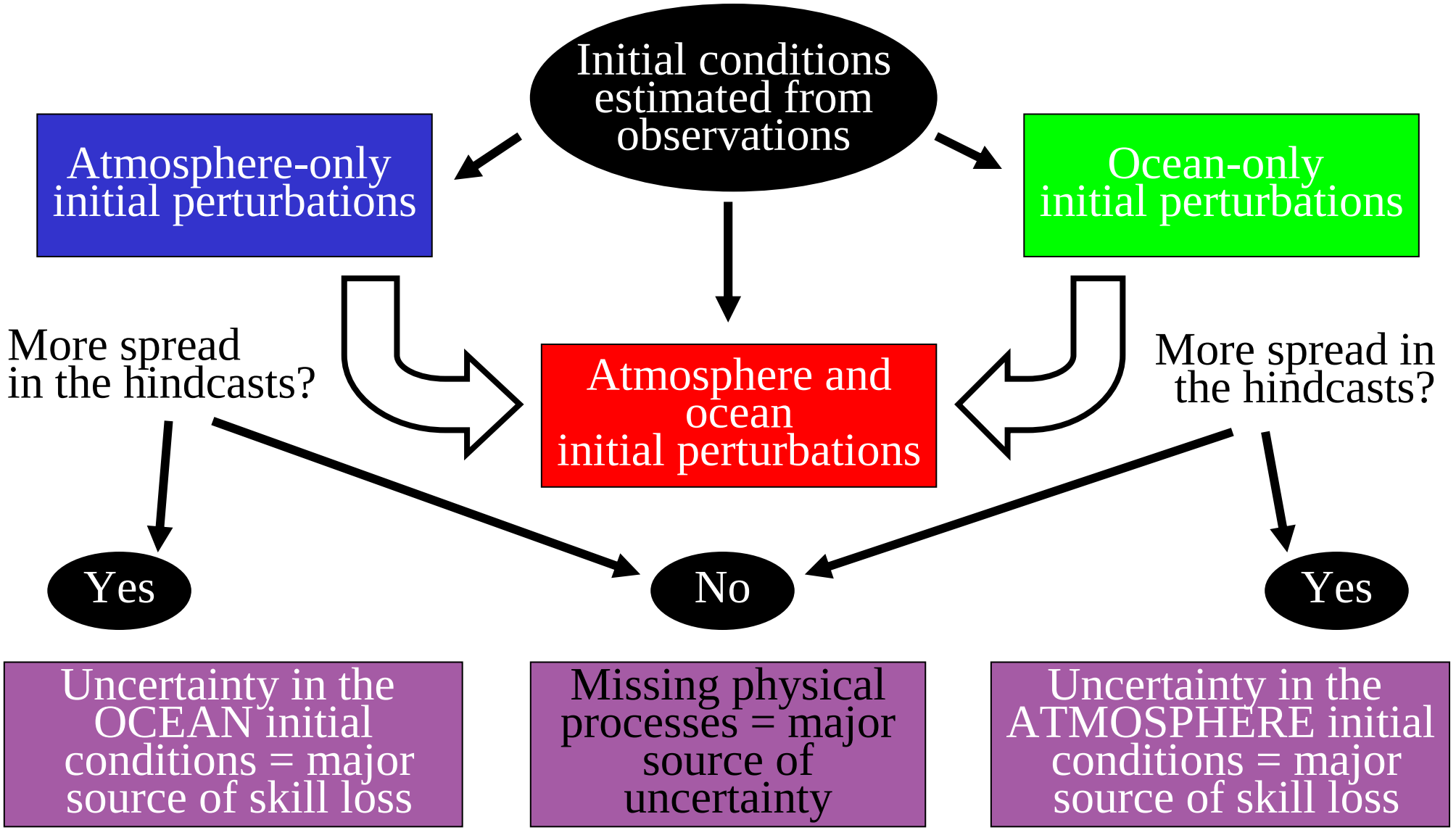
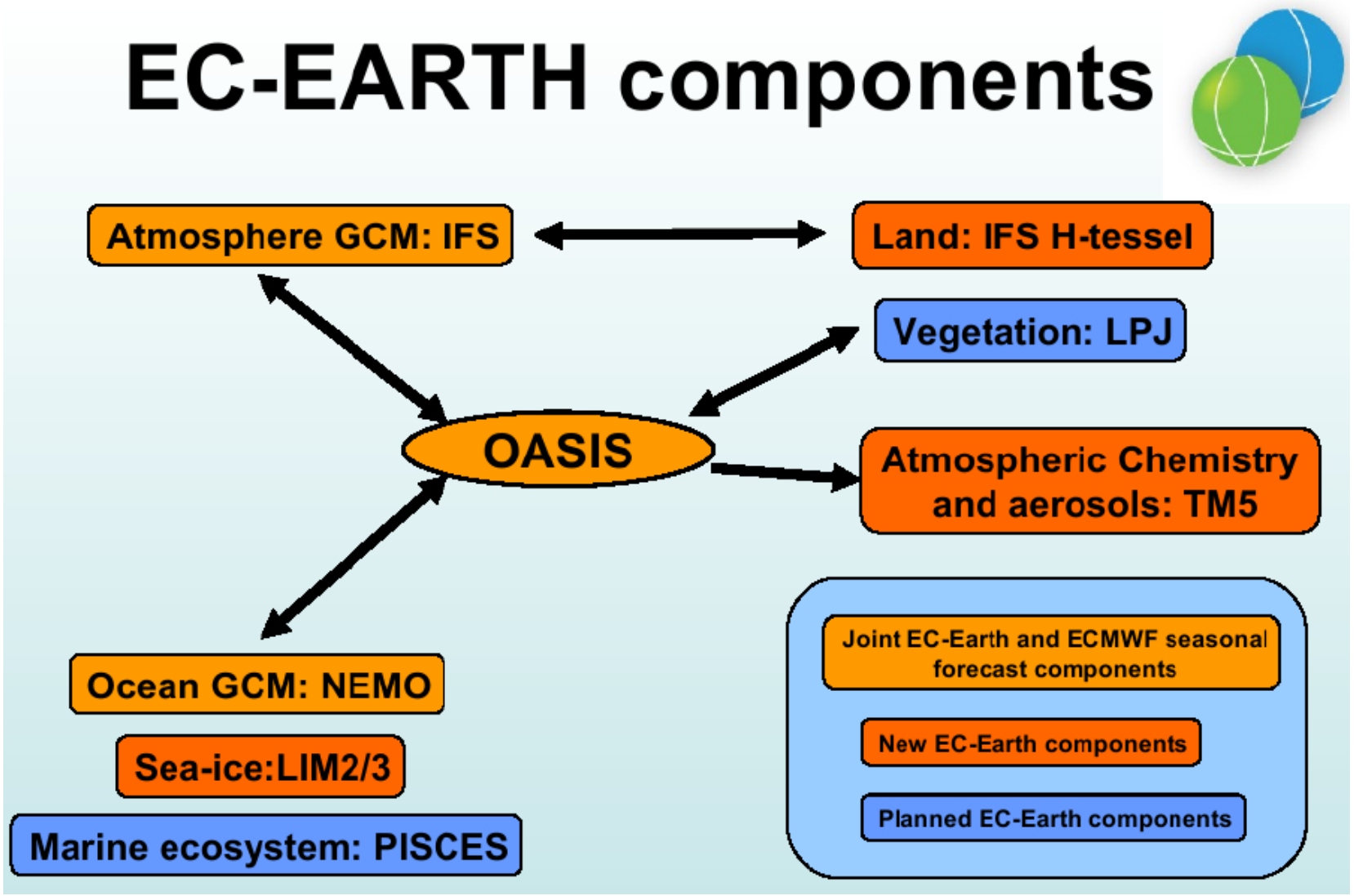
Introduction : the aim



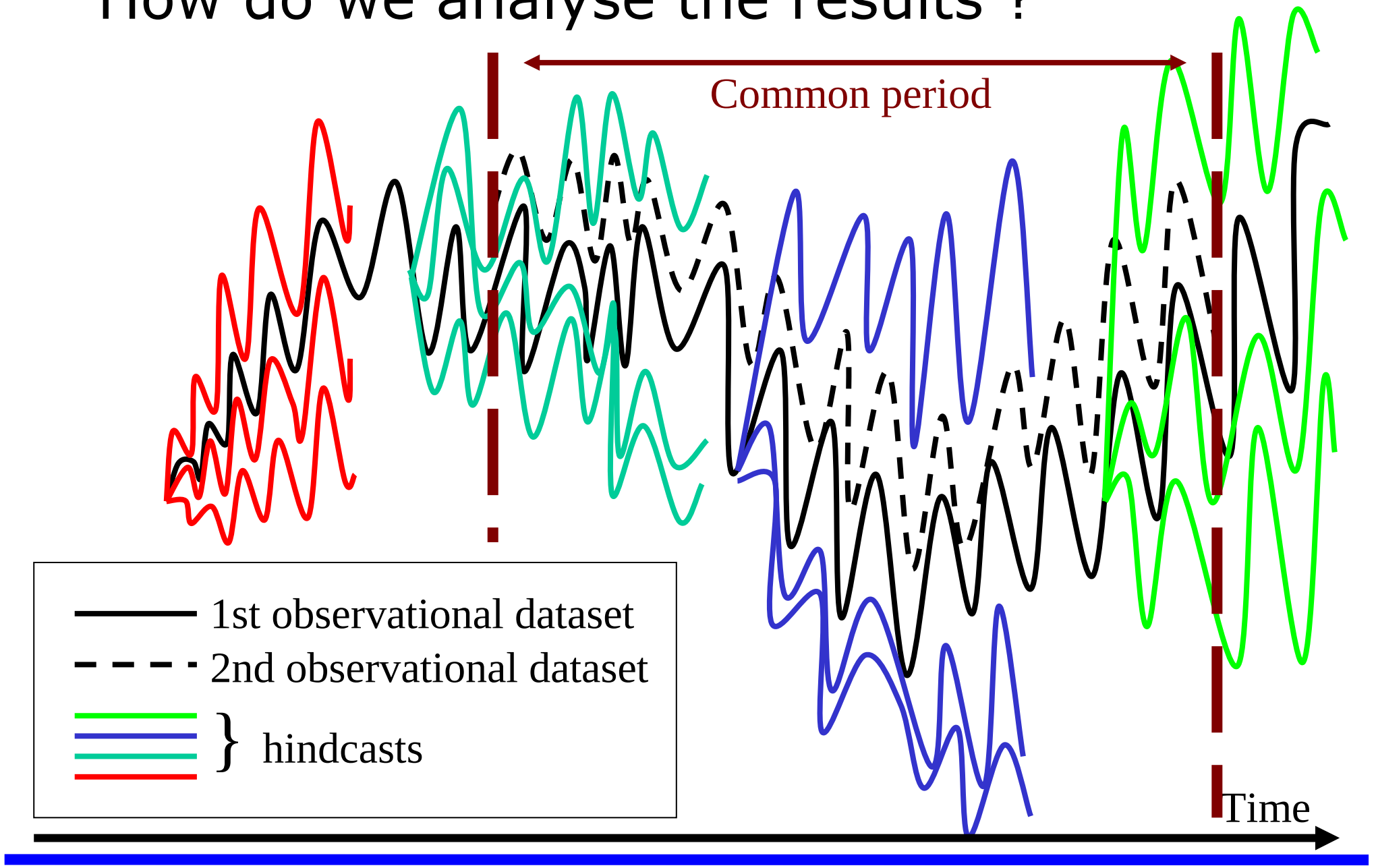
Which tool ? EC-Earth



Which experimental design ?

- Atmosphere and soil initial conditions: ERA40/ERAINT (five obtained with singular vectors, ECMWF)
- Ocean initial conditions: NEMOVAR (COMBINE, five members, ECMWF)
- Sea ice initial conditions: A single run of LIM2 forced with DFS4.3 (KNMI, SMHI)
- Three experiments :
  - Atmospheric perturbation only
  - Ocean perturbation only
  - Both Atmospheric and ocean perturbation
- 5-year long hindcasts starting November 1st, each 5 year, from 1960 to 2005

How do we analyse the results ?



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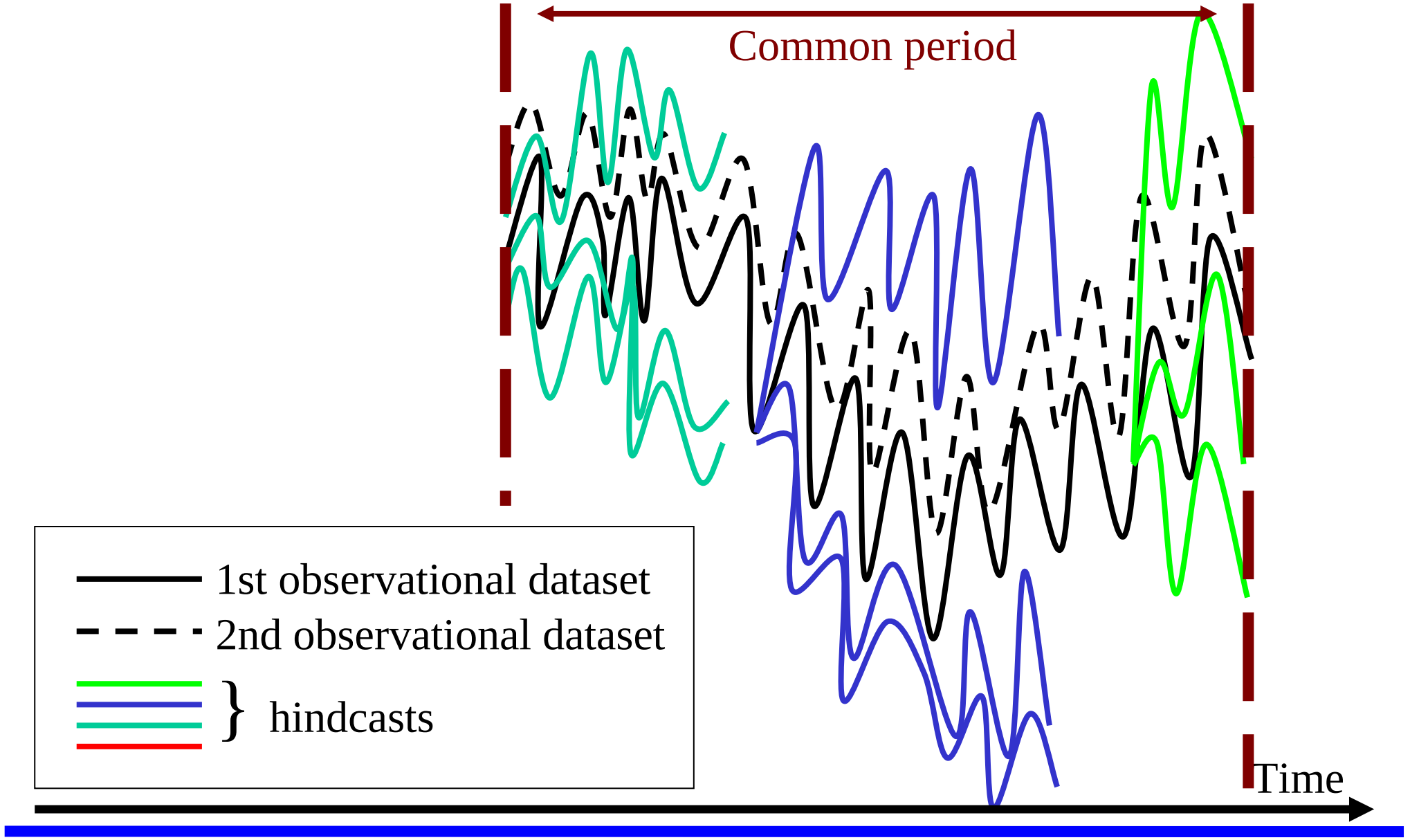

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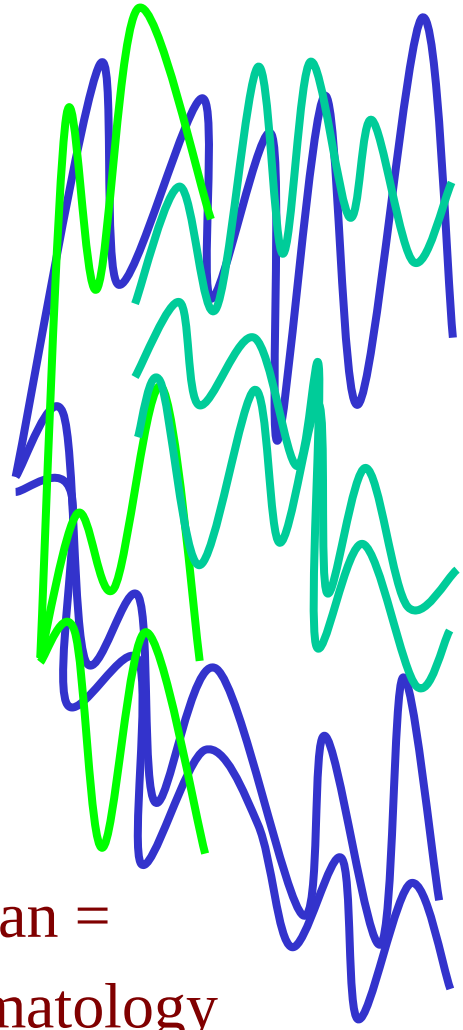


Mean =

climatology
of the hindcasts

How do we analyse the results ?

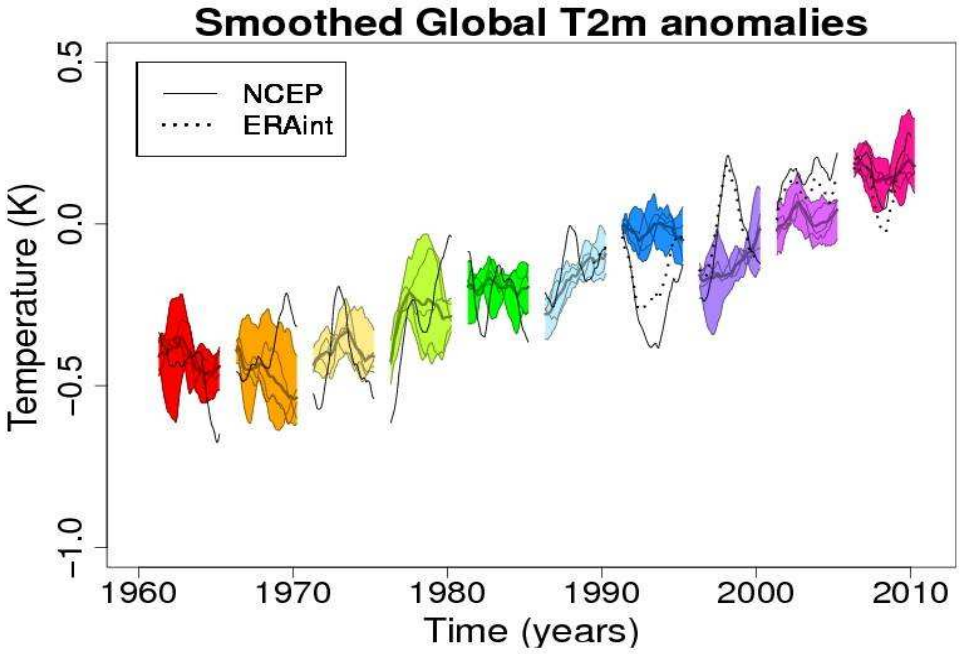
Anomalies = Raw-data - Observations/reanalyses or hindcast climatologies over the whole period, not only the common one :

1) Two-meter temperature
2) Sea ice area (Arctic/Antarctic)
3) Global ocean heat content (0-315m, 373-657m, 800m-bottom)
4) Atlantic Meridional Overturning Circulation maximum

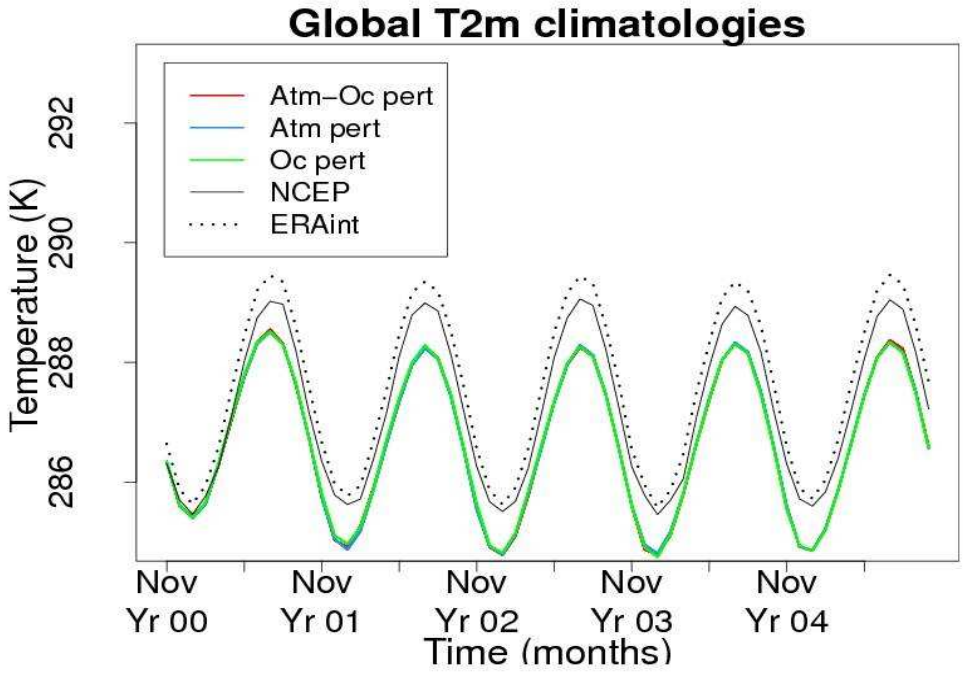
Two-metre air temperature

Global-mean temperature for EC-Earth v2.2 (pre-SO4 fix).
Anomalies smoothed out with 12-month running mean.

Atmosphere and ocean perturbations

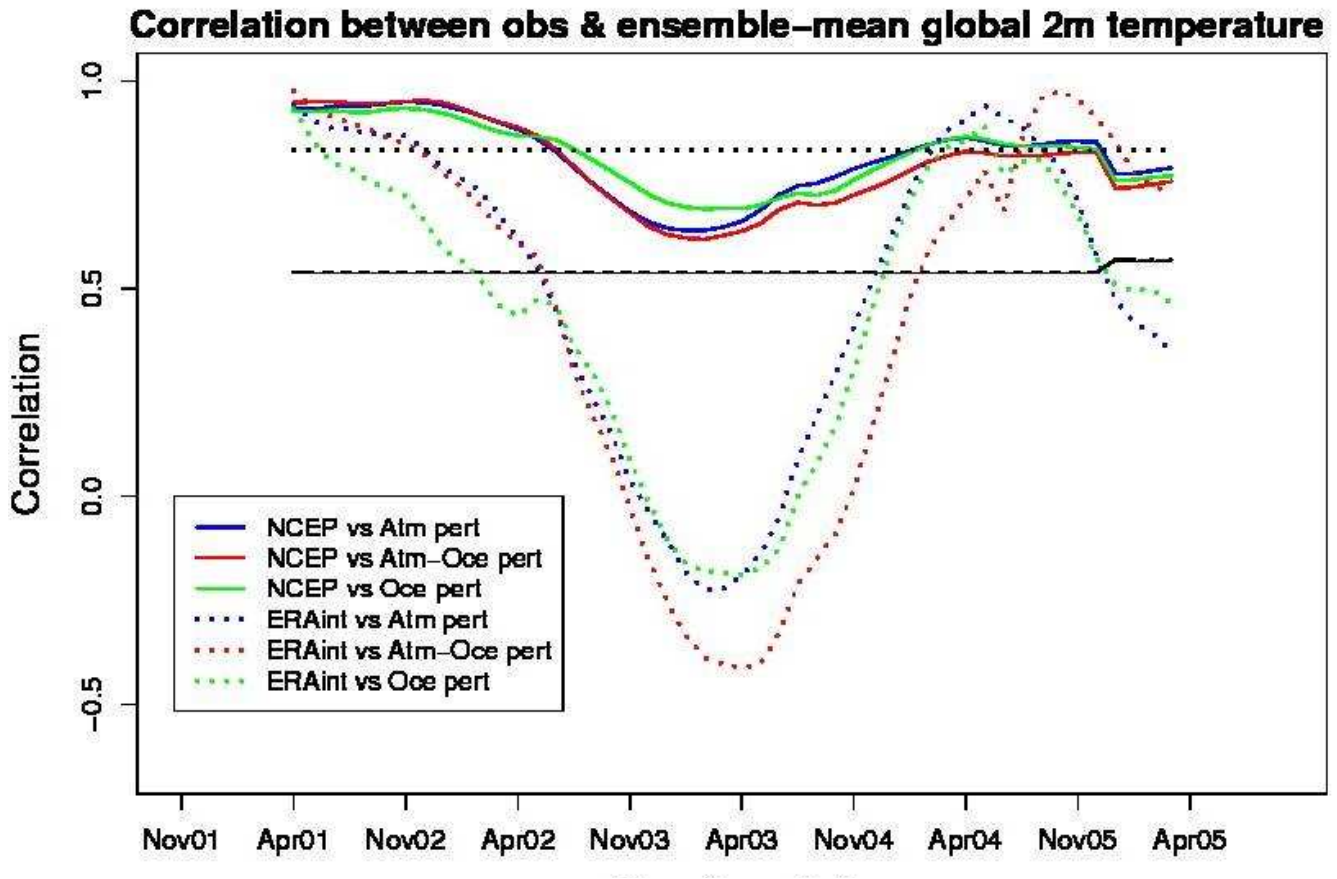


Per pairs climatologies



Two-metre air temperature

Correlations of smoothed anomalies with reanalyses



Two-metre air temperature

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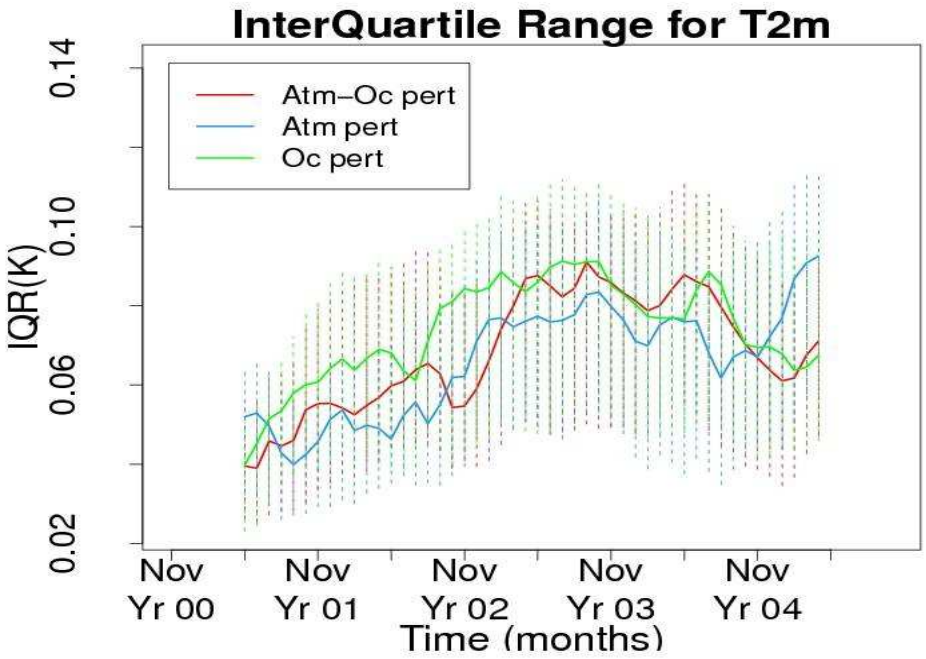
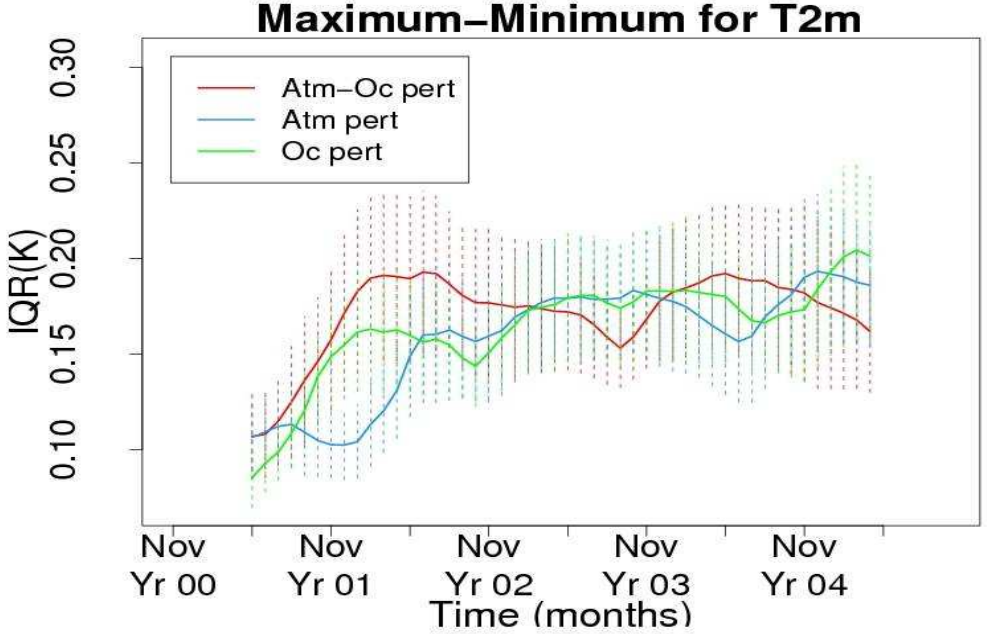
Average over the 10 starting dates of the interquartile range/ Maximum-minimum of smoothed anomalies

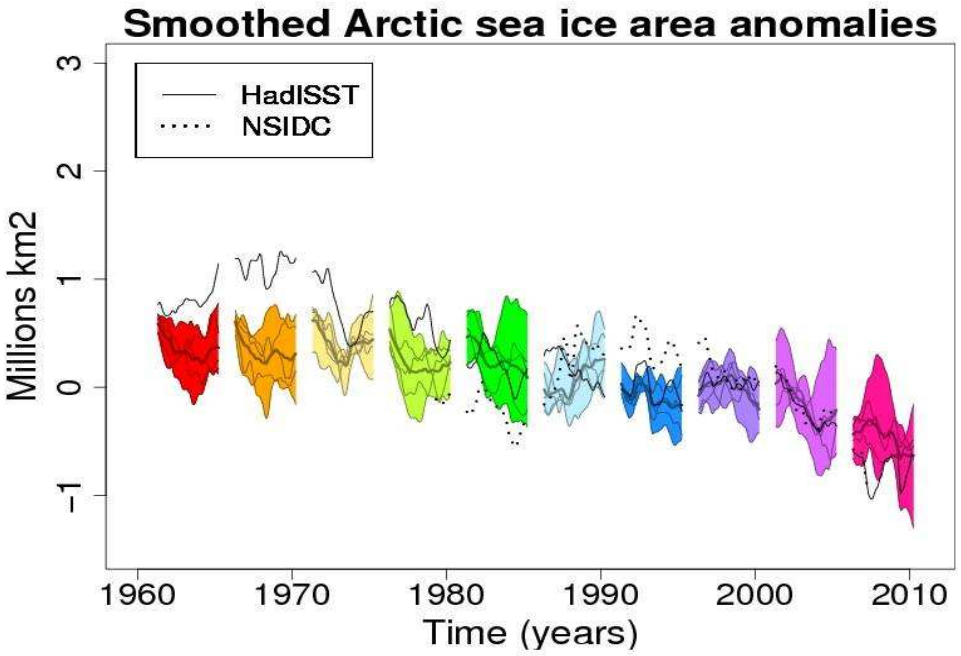




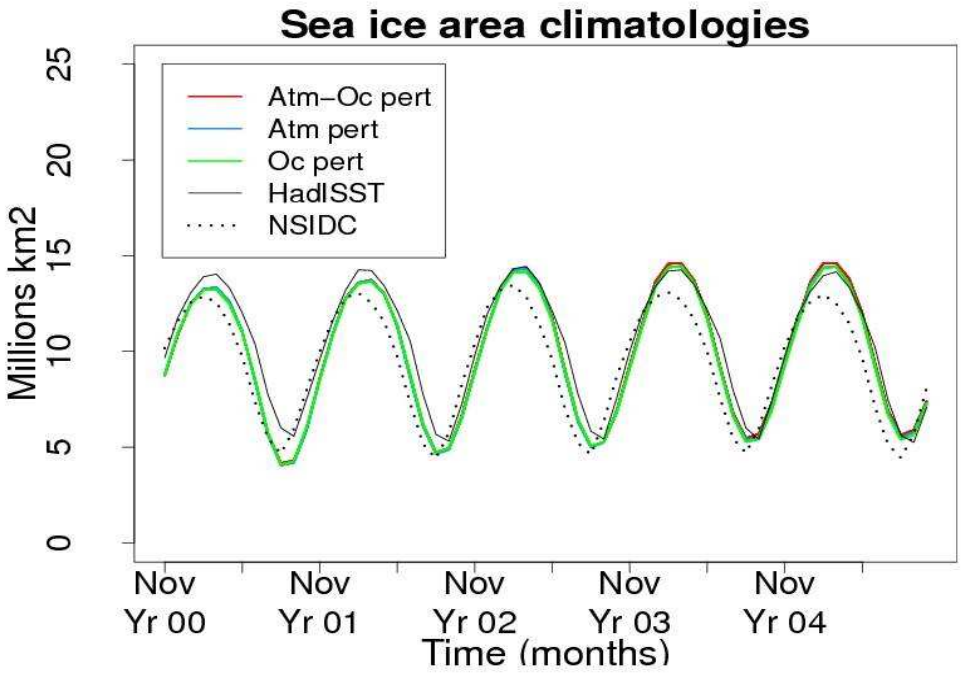
Arctic Sea ice area

Arctic sea ice area for EC-Earth v2.2 (pre-SO4 fix).
Anomalies smoothed out with 12-month running mean.

Atmosphere and ocean perturbations



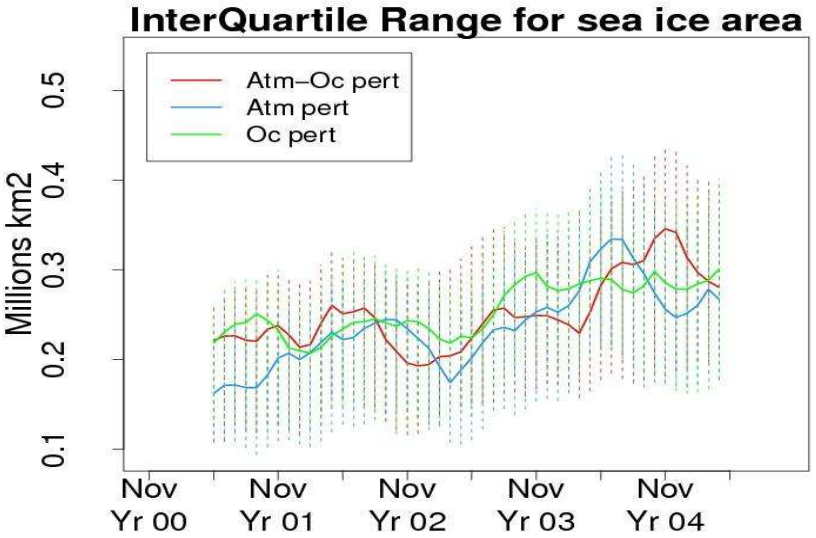
Per pairs climatologies

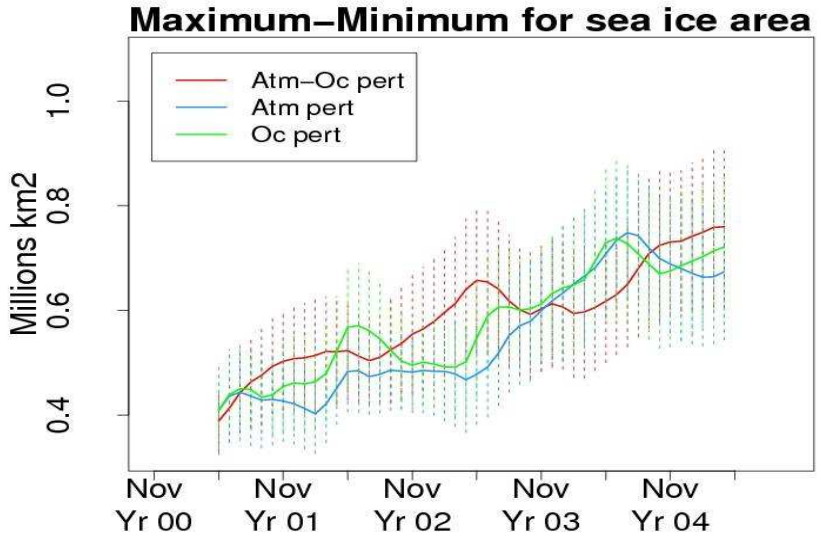


Arctic/Antarctic sea ice area

Average over the 10 starting dates of the interquartile range/ Maximum-minimum of smoothed anomalies

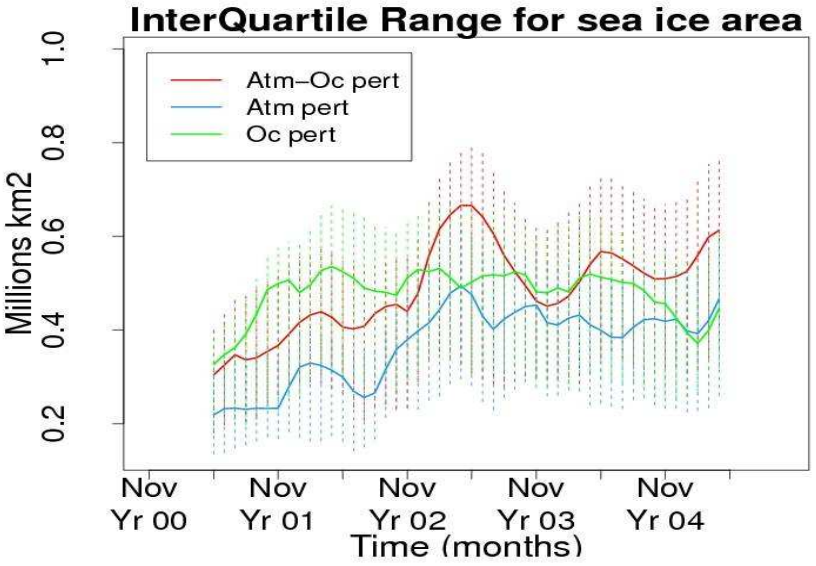
Arctic sea ice area

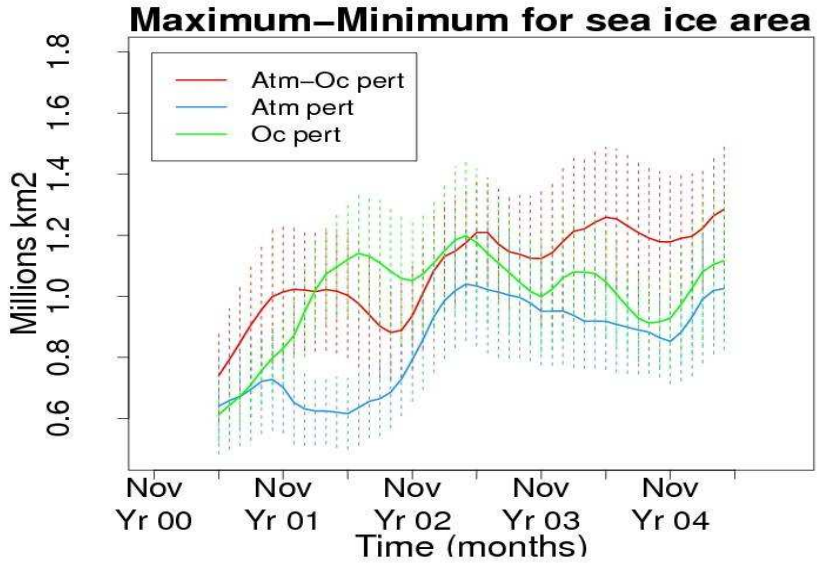




Arctic sea

Antarctic sea ice area





Antarctic sea

Global ocean heat content 0-315m

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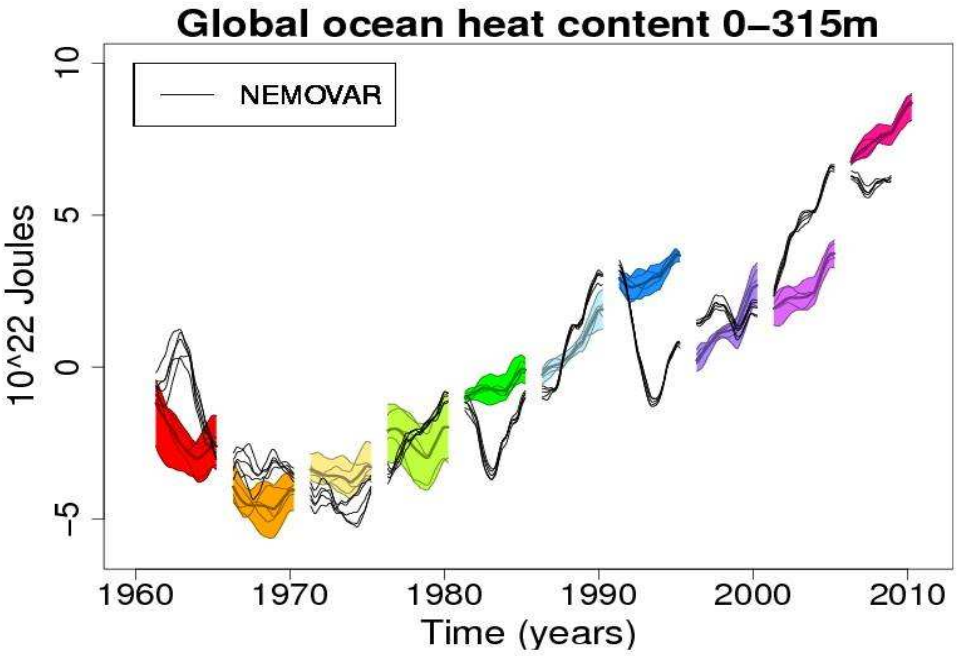
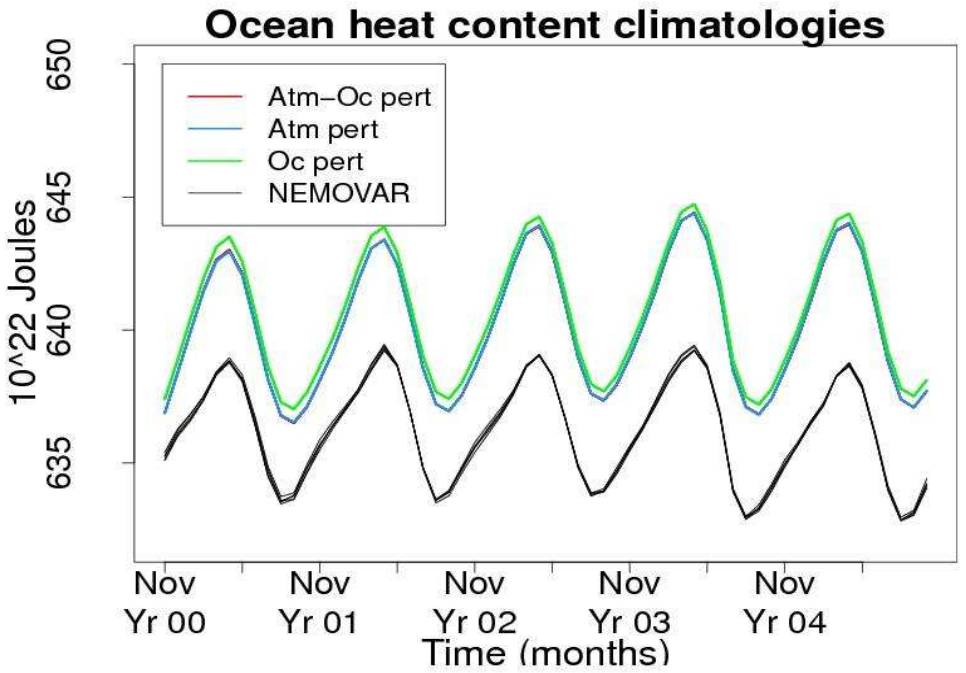
Global-mean 0-315m OHC for EC-Earth v2.2 (pre-SO4 fix).
Anomalies smoothed out with 12-month running mean.

Atmosphere and ocean perturbations



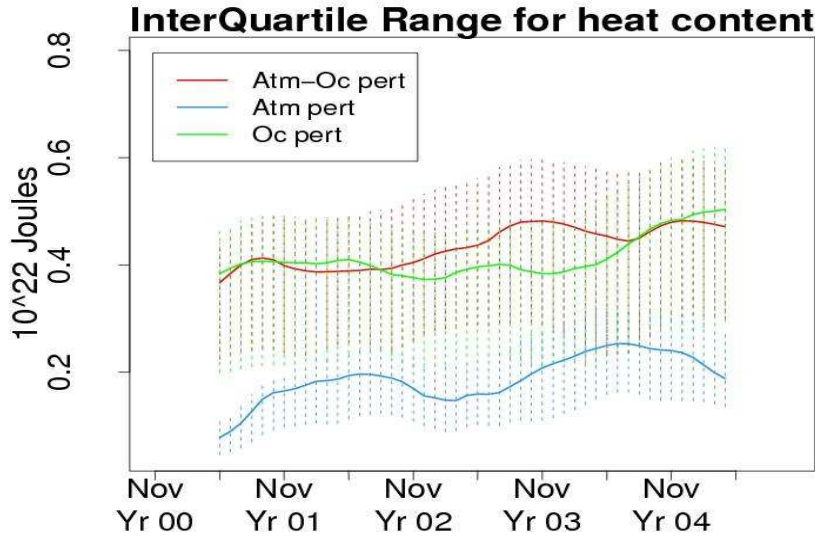
Per pairs climatologies

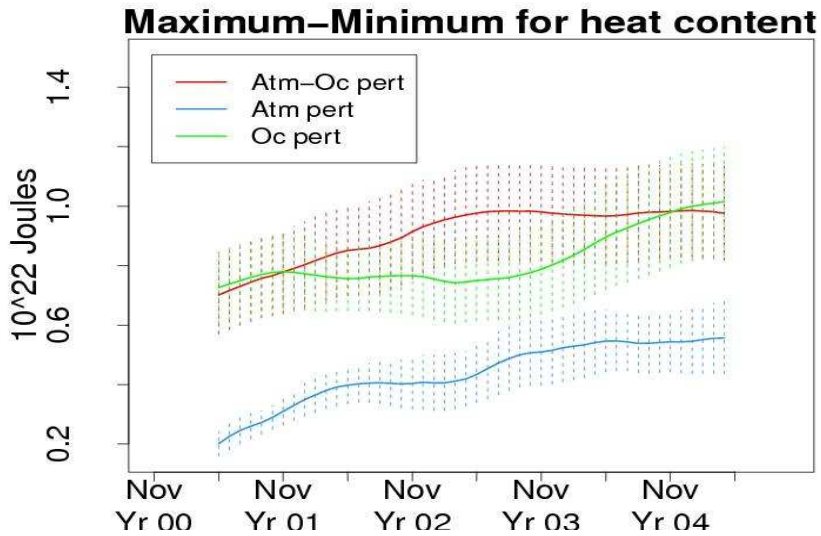


Global ocean heat content 373m-bottom

Average over the 10 starting dates of the interquartile range/ Maximum-minimum of smoothed anomalies

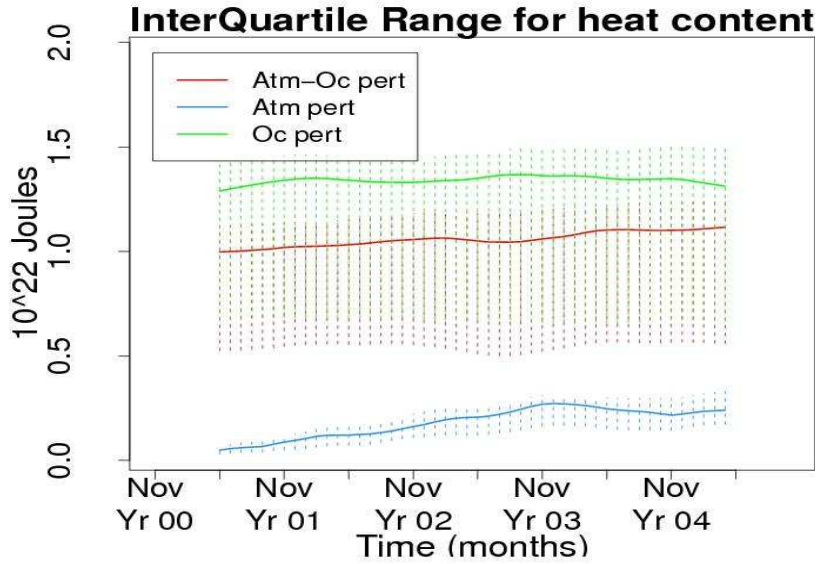
373-657m layer

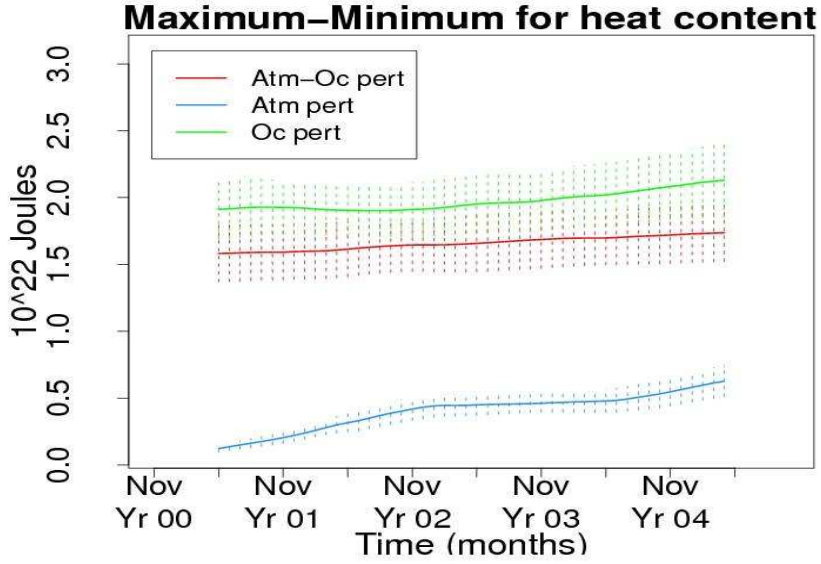




373-657m layer

800-5350m layer



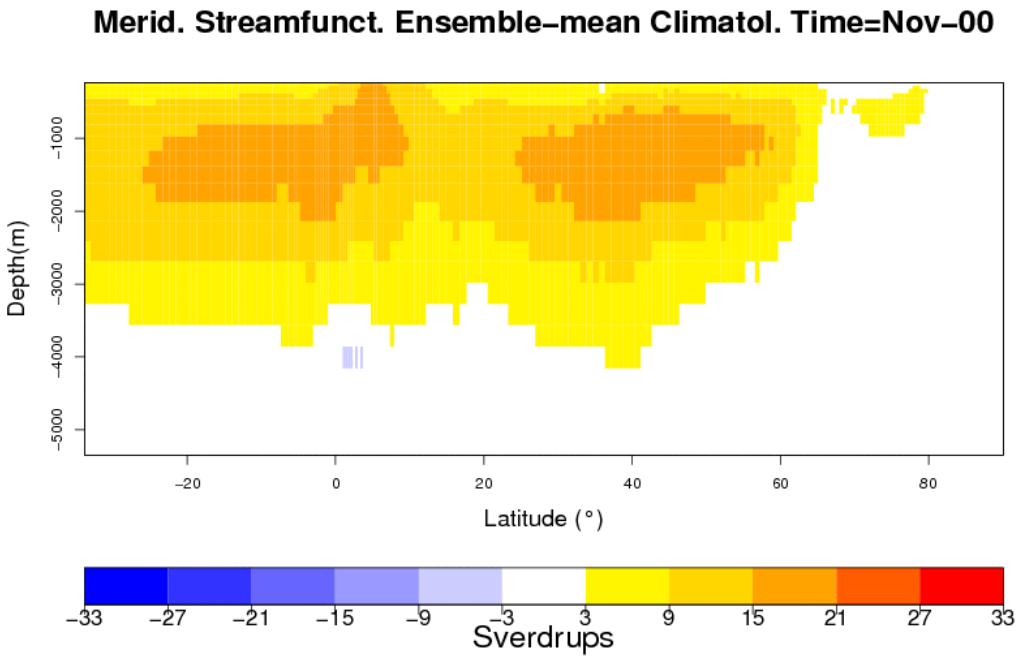


800m-5350m layer

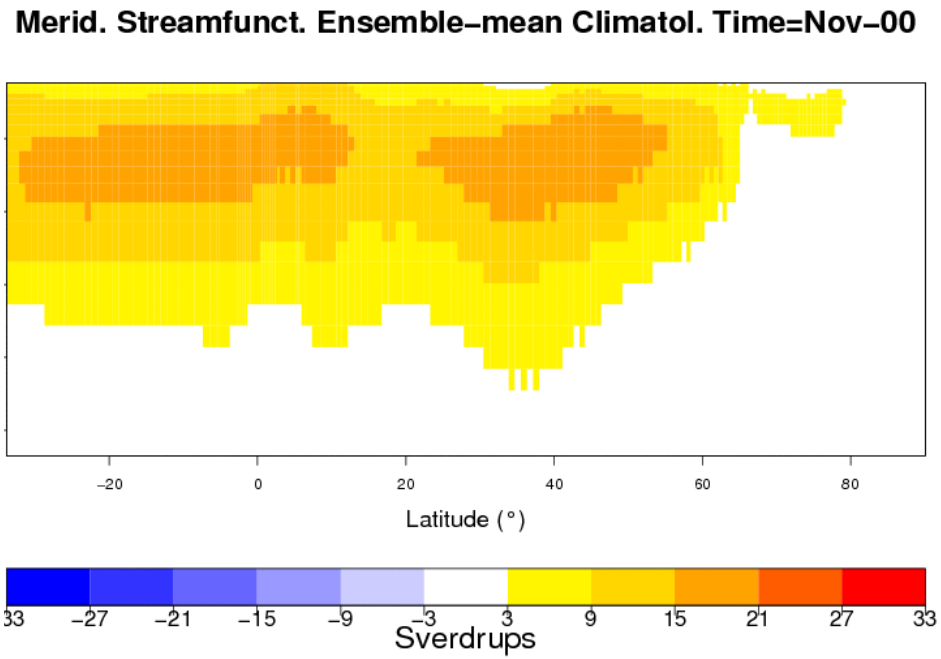
Atlantic Meridional Overturning Circulation

ensemble-mean climatologies : 250m-bottom

Atmosphere and ocean perturbations



NEMOVAR



Conclusions

1) **Two-metre temperature and SST :** cool bias + better consistency model/reanalysis in 1st half of period + more spread in year 1-3 (1-2) if ocean perturbations

2) **Sea ice cover :** more spread if ocean perturbations especially in the Antarctic

3) **Global ocean heat content :** warm bias in the upper layer, cold one in the deep ocean + more spread if ocean perturbations especially in the deep layers + bad consistency with reanalysis

4) **Maximum of the AMOC :** slightly higher than NEMOVAR reanalysis, late summer maximum more pronounced + spread roughly the same in the 3 experiments + bad consistency with reanalysis

Thank you for your attention !