Theme 2

Process-based assessment of high-resolution global climate models

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THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

PRIMAVERA

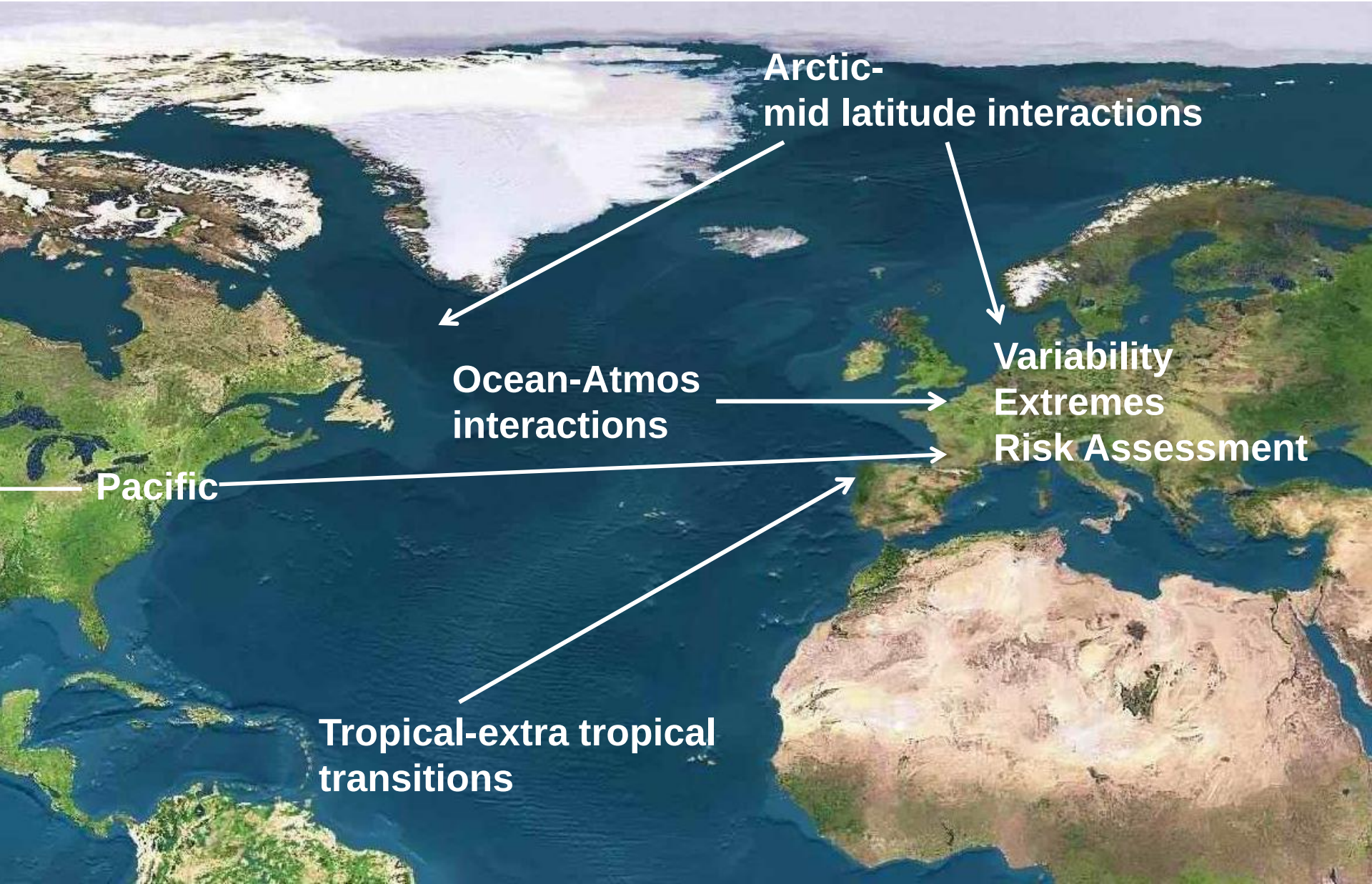
Theme 2
Main activities

i) develop new metrics for the process-based evaluation of high-resolution climate models, using diverse observational datasets

ii) apply metrics to assess systematically and objectively the benefits of higher resolution and the value of newly enabled physics

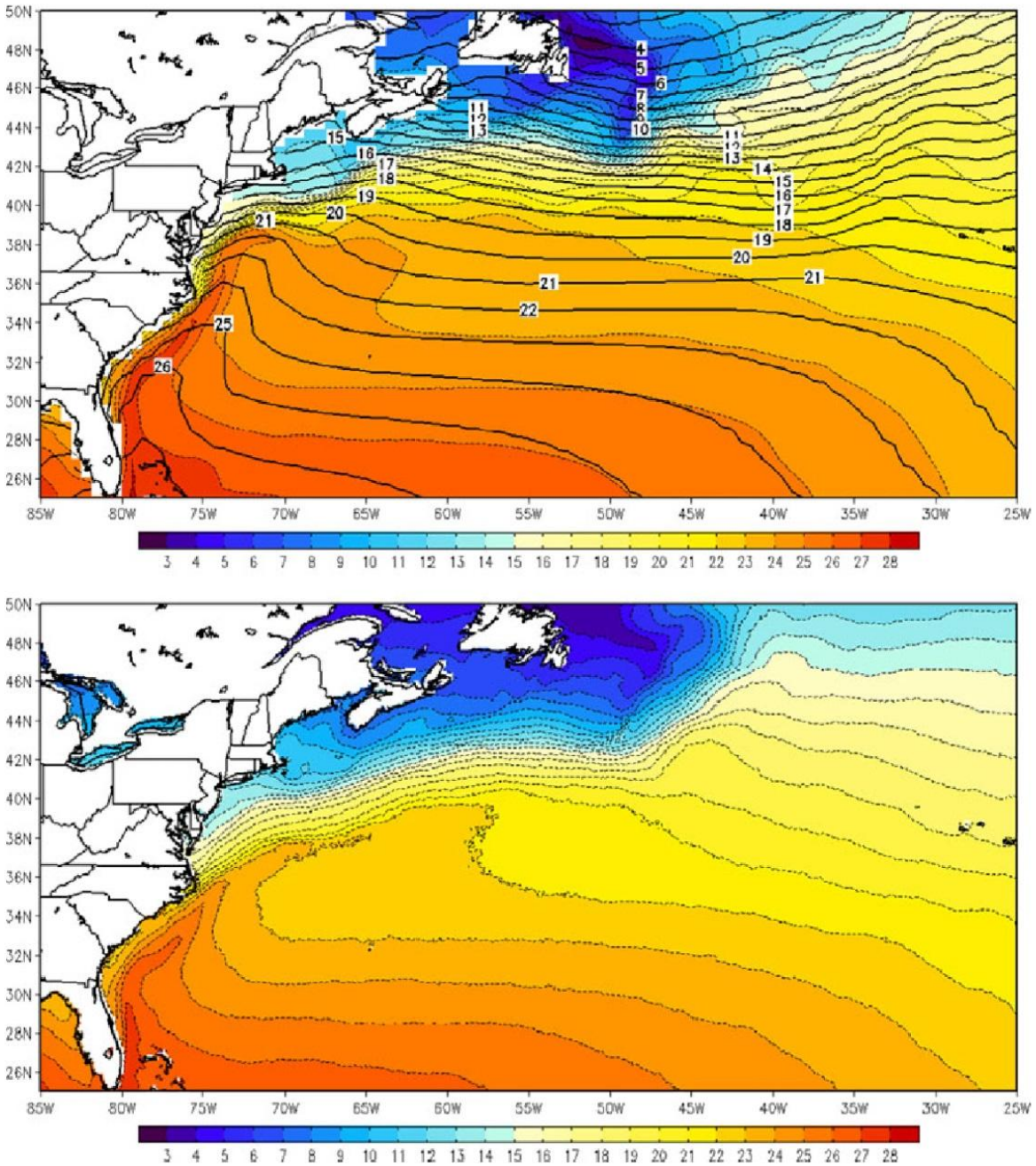
iii) explore the potential for metrics that can be used to narrow the uncertainty in projections of European climate for the next few decades

Processes


Arctic-
mid latitude interactions
Ocean-Atmos
interactions
Variability
Extremes
Risk Assessment
Pacific
Tropical-extra tropical
transitions

Example: Impact of high resolution in the ocean

Kirtman et al. 2012:
CCSM3.5
LRC: 0.5°/1.2°
HRC06: 0.5°/0.1°
→ Improved representation of position of Gulf Stream/ NA-Current



Top: time mean SST from LRC (contours) and HRC06 (shaded)
Bottom: Climatological SST from AVHRR (Kirtman et al. 2012, Fig. 7)

WP1

Development and application of metrics for process-based evaluation and projections

Objectives:

- Develop process-based metrics to assess the impact of model improvements in the atmosphere (including those related to the changes in atmospheric composition), ocean, land, cryosphere, and the interactions between the different components, with special emphasis on the simulation of the European climate.
- Develop combinations of metrics to be used in order to improve climate models by using present-day performance to attempt to reduce uncertainty in climate projections.

1. Facilitate the use of existing tools like ESMVal, AutoAssess and from the WGNE/WGCM Climate Model Metrics Panel, with increased emphasis on understanding variability and extremes due to better resolved processes.
2. A specific set of metrics will be identified for each individual component of the GCMs (atmosphere, ocean, cryosphere and land surface), together with additional cross-cutting metrics.
3. WP1 will coordinate the metric development efforts across the project
4. Metrics will be tested, as they are developed, on CMIP5 simulations and the Stream 1 simulations.

WP2

The added value of high-resolution in the atmosphere and ocean

Objectives:

- Provide a systematic assessment of the benefits of increased resolution for processes affecting European climate and its variability
- Evaluate the robustness of the response across the PRIMAVERA models and implications for future climate

Investigate the effect of high resolution in existing pre-PRIMAVERA and PRIMAVERA core-simulations, under usage of the metrics developed in WP1, on the representation of:

1. North Atlantic climate system processes and linkage to European climate variability and extremes(ocean processes and dynamics, air-sea interactions, atmosphere dynamics)
2. Arctic processes (ice melting and freezing, ocean-sea ice interactions) and impact on deep water formation and AMOC.
3. Tropical cyclones (formation and evolution), their extra-tropical transition and impact on European climate.

WP3

The role of model physics

Objectives:

- Quantify the need for improved representation or levels of complexity of a range of physical processes within the atmosphere, ocean, land and sea ice in a high resolution environment
- Develop and evaluate the impact of improved representations of key processes influencing European climate such as clouds and aerosols, land surface processes, Arctic sea ice and near-surface ocean mixing within the ensemble of high resolution simulations

1. Use process-based metrics to evaluate key processes in the models as a basis for testing new physics developments.
2. Develop and apply new metrics arising from WP1 to assess the impact of the representation of key processes on model performance in the high-resolution environment.
3. Use the latest available observational datasets appropriate for process-level evaluation
4. Assess the improved physics incorporated into Stream 2 simulations (as delivered by WP6) through existing and newly developed metrics.

Available coupled pre-PRIMAVERA simulations

Partner	Model	Control Preindustrial	Control Present day	Historical	Future/ else
MPI	MPI-ESM	T255L95/0.1L40, 50 y T63L95/0.1L40, 50 y T63L40/0.4L40, 50 y			
SMHI	EC-Earth3.01 EC-Earth3.1	200 years T255L91/ORCA1L42		1850-2005 T511/L91/ORCA025L75; 1990-2014	RCP4.5, RCP8.5 2006-2100
BSC	EC-Earth3.1 T511L91/ORCA025L75		Five 88-y-spin-ups. One 49-y long spin-up	40-ylong hist simulation: 1960-2000	
CMCC	CMCC-CM2 (CMIP6) CMCC-CM? (pre-CMIP6)	200 years 1 degree Yes (in low, middle and high res)	800 y 1 degree Yes (low, middle, high)		
MetOffice/ UReading	HADGEM3-GC2	170 y N96-ORCA025 170 y N216-ORCA025	N96-ORCA025 (100 y) N216-ORCA025 (100 y) N512 ORCA025 (100 y, 3 ens mem)	N96-ORCA025 N216-ORCA025	1% N96-ORCA025 (150y) N216-ORCA025 (150 y) 4xCO2 N96-ORCA025 (150 y); N216-ORCA025 (170 y)
CERFACS	CNRM-CM5/ CERFACS-HR		60-(maybe 100) years T359L91/NEMO025L75		

Which simulations should be used for the year-1 evaluation?
Which data should be transferred to JASMIN?

List of processes to be analyzed in year 1

Process	SMHI	BSC	MPG	U Read	KNMI	CERFACS	UCL	CMCC
Mass, heat, freshwater transports in NA	x	x	x			x		x
Ocean mixing, deep water formation	x	x	x		x	x		x
Ocean surface fronts	x	x	x		x	x		
AMOC/ AMV	x	x						x
Sub-polar gyre, heat content	x	x			x			
ocean-atm interactions/ NA variability	(x)			(x)	(x)	(x)		
ice extent, volume conc/thickness pattern	x	x					x	x
Ice drift and transports	x	x					x	x
Air-ice-ocean fluxes						x	x	x
Blocking/ storm track/ cyclones	(x)			(x)	(x)	(x)		
Mesoscales, polar lows				(x)		(x)		
Hydrological cycle, energy cycle	(x)			(x)		(x)		
Atmos heat and moisture transports	(x)			(x)				
Extreme events, P, droughts	(x)			(x)	(x)			
Tropical systems					(x)			

Define a few common metrics for each process-topic?

Metrics

What are the criteria that a good metric should fulfil?

Development rules

- The metrics will be included in a package and will be directly applicable to all participating models, creating a platform for the common interpretation of the model results obtained in other WPs.

- Observational uncertainty will be taken into account.

- Appropriate output lists will be discussed with WP9.

- Statistical inference should be applied specifically to each metric.

- The metrics will complement (and integrate with) preexisting tools/packages.

→ Development criteria agree well with the ***SOSIE*** criteria:
Scope, Observability, Stability, Interpretability, Exposure

Reference Data

Model reference data

CMIP5 (for year 1)?

Observations (proposed by partners):

ECA&D E-OBS; MESAN
ERA40/ERA-interim/ ERA5 reanalyses
Best Track, satellite data
HadISST, EN4 ocean analyses, HadSLP, Atm Reanalysis for U850
MERRA, GPCC, CMORPH
20CR, NCEP/-NCAR, ERSST, GPCP, OAFLUX
ORAP5, GLORYS2V3, OSISAF, ICE-Sat, SMMR/SSMI, ARGO-floats
Jena-BGI, GRACE measurements

Question

Define one reference data set for each metric or use entire range to better capture uncertainties?

Metrics and Tools

Range of tools used by partners:
ESMVAL; CDO; CDFTOOLs; MATLAB; Grads; Ferret; Python; NCL; Fortran; PAGO; s2dverification; R;
different blocking and tracking codes;
ice-diagnostics: OWFE; HCI; ice thickness/dynamics relationship

Questions:
How to best organize a common usage of tools?
All analysis on JASMIN or mainly locally (related to data transfer)?
Preparedness of JASMIN for installation of the tools used by the partners?

PROPOSAL: All process analyses planned in WPs 2, 3 and 4 should be listed along with the tool planned to perform the task to identify commonalities, reduce duplication and allow comparability.

Align with CRESCENDO.

Upcoming Milestones and deliverables

M2: List of existing past-CMIP5 simulations and high-resolution observational data
M4: Exchange of outputs from the past-CMIP5 simulations and observational data
M6: Observational/reanalysis/CMIP5 datasets available on JASMIN
M12: Strategy for integrating the metrics software available in the different partner institutions
M12: Plan and tools for process-based analysis of core simulations

D2.1, M15: Assessment of the benefits of increased resolution across the pre-PRIMAVERA multi-model ensemble
D1.1, M18: First examples of the application of common process-based metrics to existing climate experiments
D3.1, M24: Quantification of robustness of aerosol-radiation-cloud interactions across models and resolutions