PRIMAVERA

Malcolm Roberts, Met Office (coordinator)
Pier Luigi Vidale, Univ. of Reading (scientific coordinator)
Paul van der Linden, Met Office, (project manager)

PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment

Goal:

- to deliver novel, advanced and well-evaluated high-resolution global climate models (GCMs), capable of simulating and projecting regional climate with unprecedented fidelity, out to 2050.

To deliver:

- innovative climate science and a new generation of European advanced GCMs.
- improve understanding of the drivers of variability and change in European climate, including extremes, which continue to be characterised by high uncertainty
- new climate information that is tailored, actionable and strengthens societal risk management decisions with sector-specific end-users
- new insights into climate processes using eddy-resolving ocean and explicit convection atmosphere models

To run for 4 years from Nov 2015 including 19 partners across Europe, funded by the Horizon 2020 call SC5-1-2014 - Advanced Earth System Models – grant no 641727

www.primavera-h2020.eu

Core integrations in PRIMAVERA will form much of the European contribution to CMIP6 HighResMIP

http://www.wcrp-climate.org/index.php/modelling-wgcm-mip-catalogue/429-wgcm-hiresmip

Aims and ambitions

- Robust understanding of the role of resolution in process representation
  - Metrics and assessment are key
- Better understand the appropriate combination of resolution and complexity
  - What complexity is suited to what resolution and vice versa
  - Clear links with CRESCENDO here
- Providing actionable climate information for sector-specific end users

Co-funded by
the European Union

PRIMAVERA goals and objectives

Goal:

- to deliver novel, advanced and well-evaluated high-resolution global climate models (GCMs), capable of simulating and projecting regional climate with unprecedented fidelity, out to 2050.

To deliver:

- innovative climate science and a new generation of European advanced GCMs.
  - Including delivery to CMIP6 HighResMIP international comparison via ESGF
  - Coordination of HighResMIP analysis, particularly as relates to Europe
- improve understanding of the drivers of variability and change in European climate, including extremes, which continue to be characterised by high uncertainty
- new climate information that is tailored, actionable and strengthens societal risk management decisions with sector-specific end-users
- new insights into climate processes using eddy-resolving ocean and explicit convection atmosphere models
- Engagement and communication with key communities (e.g. WGCM, GEWEX) and policy makers

Co-funded by
the European Union

PRIMAVERA themes and work packages

Table 1.3.1: Correspondence between Themes and work packages

	Corresponding work packages in the work plan
Theme 1 Innovations in modelling and exploring the frontiers of climate modelling	WP1 - Development and application of metrics for process-based evaluation and projections WP3 - The role of model physics WP4 - Frontiers of Climate Modelling WP6 - Flagship simulations
Theme 2 Process-based assessment of high-resolution global climate models	WP1, 3, 4 WP2 – The added value of high-resolution in components of the physical climate system WP5 - Drivers of variability and change in European climate
Theme 3 The drivers of European climate variability and change	WP2, 3, 5
Theme 4 Flagship simulations for CMIP6 and IPCC AR6	WP4, 6
Theme 5 Climate risk assessment and user engagement	WP8 – Scientific coordination WP10 - Climate Risk Assessment WP11 – End-user Engagement and Dissemination

Co-funded by
the European Union

Work Packages

- WP1 – led by Paco Doblas-Reyes (BSC) and Alessio Bellucci (CMCC)
  - Process-based metrics development to assess model improvements due to resolution/complexity
  - Develop combined metrics in order to improve climate models by using present-day performance in attempt to reduce uncertainty in projections

- WP2 – led by Thomas Koenigk (SMHI) and Virginie Guemas (BSC)
  - Systematic assessment of impact of (horizontal) resolution on processes affecting European climate simulation
  - Evaluate robustness of response across model ensemble and implications for future projections

- WP3 – led by Cath Senior (MO)
  - Quantify need for improved representation or levels of complexity of range of physical processes in high resolution environment
  - Develop and evaluate impact of improved representations on European climate in four areas:
    - Aerosol, radiation, cloud interactions – e.g. double-moment schemes – Nicholas Bellouin (UREAD)
    - sea-ice – e.g. Rheology – Dorotea Iovino (CMCC)
    - Ocean – near-surface mixing representation e.g. OSMOSIS, sub-mesoscale params – Adrian New (NOC)
    - land-atmos coupling – Alessio Bellucci (CMCC) temporarily

Work Packages

- WP4 – led by Malcolm Roberts (MO) and Jin-Song von Storch (MPG)
  - Develop next generation of coupled climate models by exploring concept of "Beyond simple parameterisation" in four areas:
    - Uniform resolution increase: eddy-resolving ocean, explicit convection atmosphere and microphysics at km-scale – regional → global, vertical resolution
    - unstructured mesh approaches to target resolution in ocean/sea-ice model,
    - stochastic physics to better represent sub-gridscale processes
  - Assess relative benefits and costs of each approach and provide recommendations for future

- WP5 – led by Laurent Terray (CERFACS) and Rowan Sutton (UREAD)
  - Improve understanding of key oceanic physical and dynamical drivers and mechanisms leading to decadal variability of European climate
  - Assess influence of regional climate phenomena
  - Quantify respective response to oceanic modes and anthropogenic radiative factors
  - Assess robustness of response to drivers across model resolution and physics complexity

- WP6 – led by Rein Haarsma (KNMI) and Johann Jungclaus (MPG)
  - Deliver core flagship simulations at low and high resolution, both coupled and forced atmosphere, using HighResMIP protocol
  - Coordinate delivery and availability of core model datasets throughout project

Co-funded by
the European Union

PRIMAVERA

Work Packages

- WP7 – led by Paul van der Linden (MO), Malcolm Roberts (MO) and Pier Luigi Vidale (UREAD)
  - Establish good management practices
  - Coordinate relationships within project
  - Establish and maintain an effective working relationship between PRIMAVERA and the European Commission (EC)

- WP8 – led by Pier Luigi Vidale (UREAD) and Malcolm Roberts (MO)
  - Establish and maintain the scientific excellence and coordination of PRIMAVERA, to ensure that the scientific objectives and impacts of the project are achieved
  - Formulate high level synthesis of results
  - Establish effective communication between project and wider scientific community, governments etc

- WP9 – led by Matthew Mizielinski (MO) and Ag Stephens (STFC)
  - Plan for required HPC for project simulations
  - Data management and dissemination

Co-funded by the European Union

Work Packages

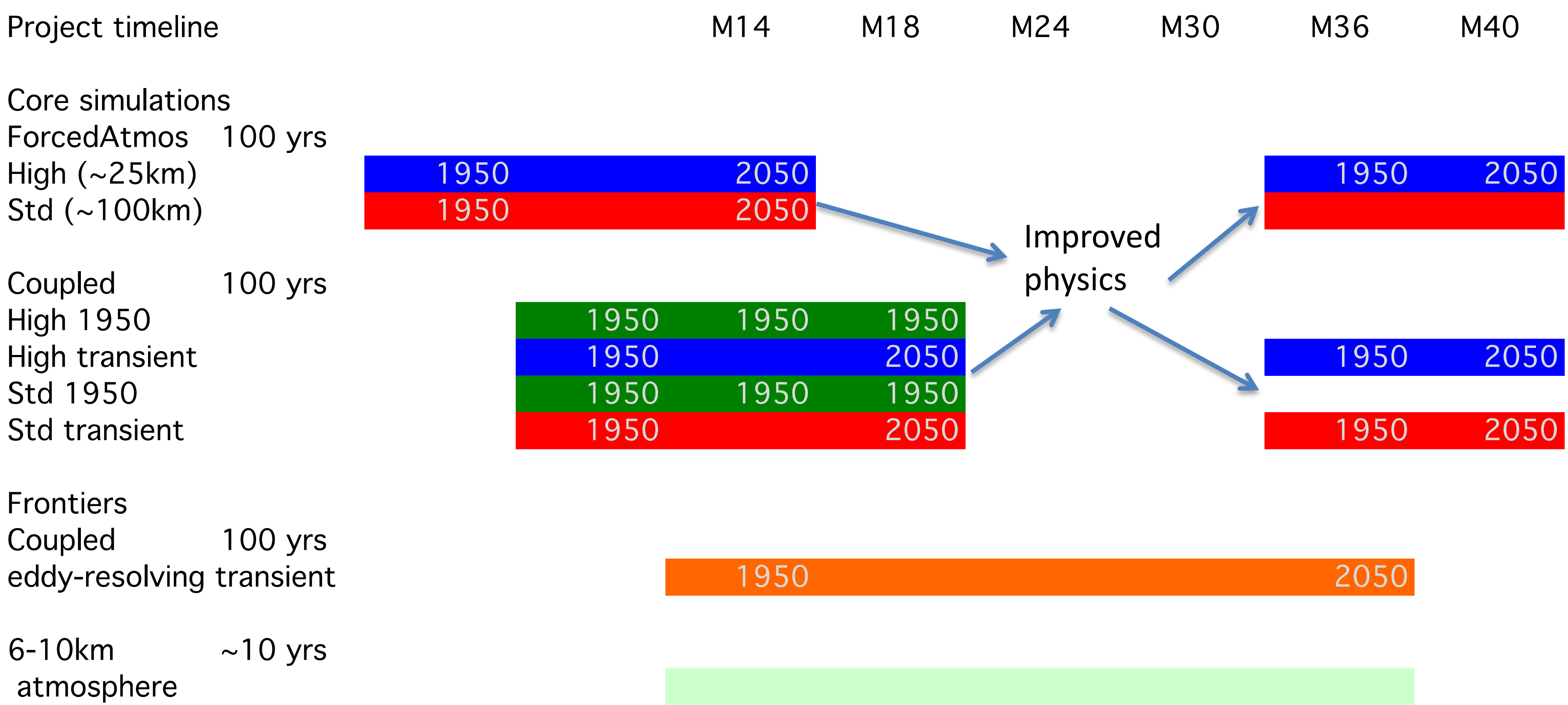
- WP10 – led by Ge Verver (KNMI) and David Brayshaw (UREAD)
  - Assess representation of physics and meterological hazards
  - Develop scientifically based narratives for input to risk assessments – extremes and compound events affecting Europe
- WP11 – led by Melanie Davies (BSC) (Isadora Jiménez (BSC) currently) and Erika Palin (MO)
  - To advance the communication and scientific information needed to develop climate risk response strategies
  - Engage with end user groups from key economic sectors:
    - Wind energy, transport, power system, finance and insurance
  - To ensure effective dissemination and communication to business sector end users

Co-funded by the European Union

Core Integrations

- Forced Atmosphere
  - 1950-2050 (1/4 degree, daily SSTs, simplified aerosol forcing)
  - Standard (e.g. CMIP6) and high resolutions, 60km-100km and ~25km
  - Ensembles >= 1
- Coupled AOIL
  - 1950-2050
  - Standard and high resolution (in both/either atmosphere and ocean)
  - Fixed 1950's forcing vs all forcings (RCP8.5)
  - Ensembles >= 1
- Intend to use simplified aerosol forcing (rather than emissions) to reduce spread between models and better understand processes
- Frontiers integrations
  - Coupled model with 1/10° – 1/12° ocean, 100 years, 3-4 groups
  - Stochastic physics at standard and high resolution
  - Unstructured mesh FESOM ocean/sea-ice coupled to ECHAM6
  - Horizontal resolution → allowing explicit convection ~6km → link to microphysics being developed in regional sub-km domains

Core and frontier simulations and timeline



In addition

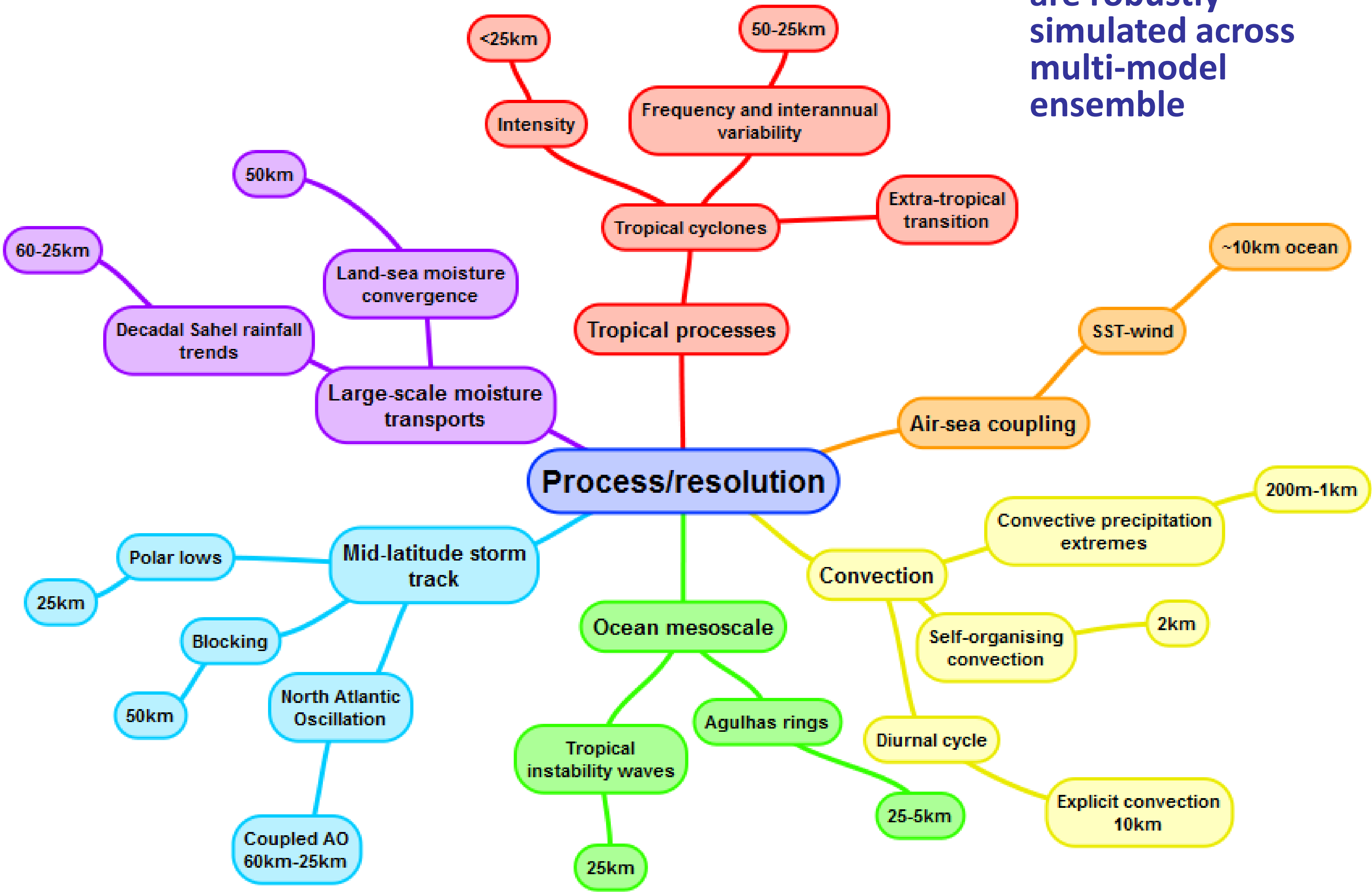
- Simulations to understand scenario and risk uncertainty
- Sensitivity studies for improved model physics
    - Land surface, ocean, sea ice, clouds and aerosols

Co-funded by
the European Union

PRIMAVERA

Example map of climate process and model resolution required – metrics key

Aim: to discover at what resolution climate processes are robustly simulated across multi-model ensemble



Process understanding

- Detailed model process evaluation
  - Moving away from using monthly means and climatologies towards high frequency interactions and extreme processes
  - Requires much more detail from observations and reanalyses
- Precipitation and energy
  - Precip over land, sea, orography
  - Using models to try and interpret observations, constraints
  - Understand whether model or observational biases
  - Demorygram – hydrological cycle, tying together energy and water
- Air sea interactions
  - Models typically have weaker coupling than "observed"
  - Possibly relates to weak signal to noise – e.g. Large ensembles required
  - Need co-located SST, wind, flux, moisture in order to understand interactions, at high frequency
- Diurnal cycle
  - Cloud, soil moisture, water vapour, temperature, precipitation

Co-funded by
the European Union

PRIMAVERA

PRIMAVERA and CMIP6 HighResMIP

Horizon 2020
PRIMAVERA
European focus
Model assessment and metrics
Model development
Frontier simulations
Drivers of clim var
Inform climate risk

Main European contribution to HighResMIP

CMIP6
HighResMIP
International community
Multi-model global high & std resolution climate simulations
Robustness of changes with model resolution
Primary question: systematic biases

Resolution is our chosen tool for investigation and understanding
Ensembles, complexity, parameter uncertainty and initialisation are other axes
All need suitable datasets for assessment

Co-funded by the European Union

European HighResMIP model resolutions (as part of PRIMAVERA)

Institution	MO NCAS	KNMI IC3 SMHI CNR	CERFACS	MPI	AWI	CMCC	ECMWF
Model names	MetUM NEMO	ECEarth NEMO	Arpege NEMO	ECHAM MPIOM	ECHAM FESOM	CCESM NEMO	IFS NEMO
Atmosph. Res., core	60-25km	T255-799	T127-359	T63-255	T63-255	100-25km	T319-799
Oceanic Res., core	¼ º	¼º	¼	0.4-¼º	1-¼ spatially variable	¼	¼
Oceanic Res., Frontiers	1/12˚	1/12˚		1/10˚	1/10˚ Spatially variable		

- Emphasis on horizontal resolution – keep vertical resolution the same
- Global atmosphere resolutions: range from 150km to 6km
- Global ocean resolutions: from 1˚ to 1/12˚

Co-funded by the European Union