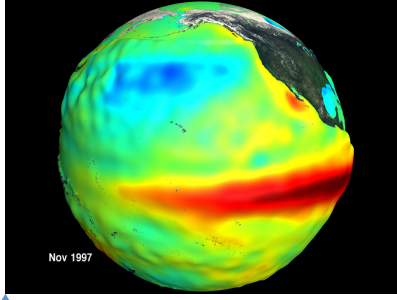
HighResMIP

Slides provided by
Rein Haarsma KNMI (lead)
Malcolm Roberts Met Office (co-lead)

- Important weather and climate processes emerge at sub-50km resolution
- They contribute significantly to both large-scale circulation and local impacts, hence vital for understanding and constraining regional variability
- How robust are these effects?
- Is there any convergence with resolution across models?

Need coordinated, simplified experimental design to find out

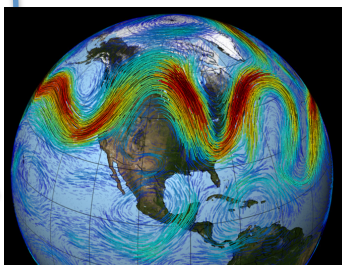
http://www.wcrp-climate.org/index.php/modelling-wgcm-mip-catalogue/429-wgcm-hiresmip

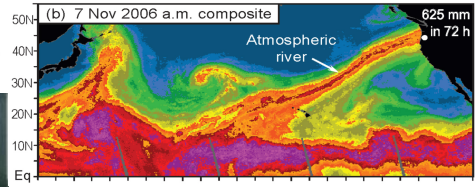


Global drivers

Regional variability

Feedbacks to large scale





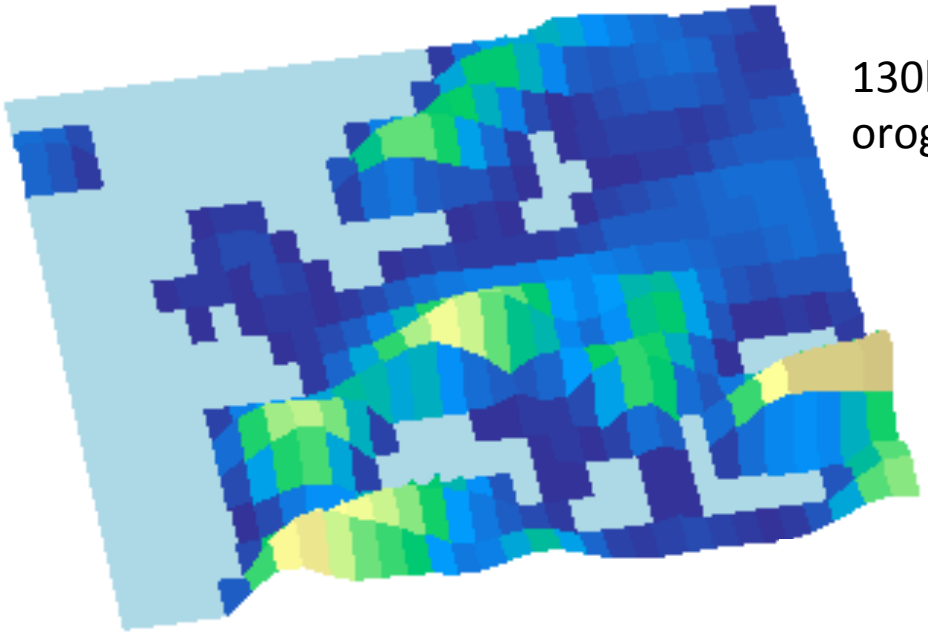
Local processes

Impacts, extremes

Experimental protocol:
Global models – AMIP-style and coupled
Physical climate system only
Integrations: **1950-2050**
Ensemble size: >=1 (ideally 3)
Resolutions: **<25km HI and ~60-100km STD**
Aerosol concentrations specified

e.g. Zhao et al, 2009; Haarsma et al, 2013; Demory et al, 2013

Global HighResMIP resolution representation of orography



130km resolution orography

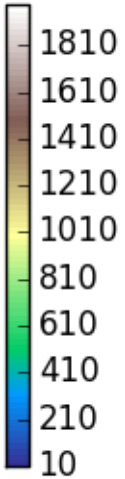
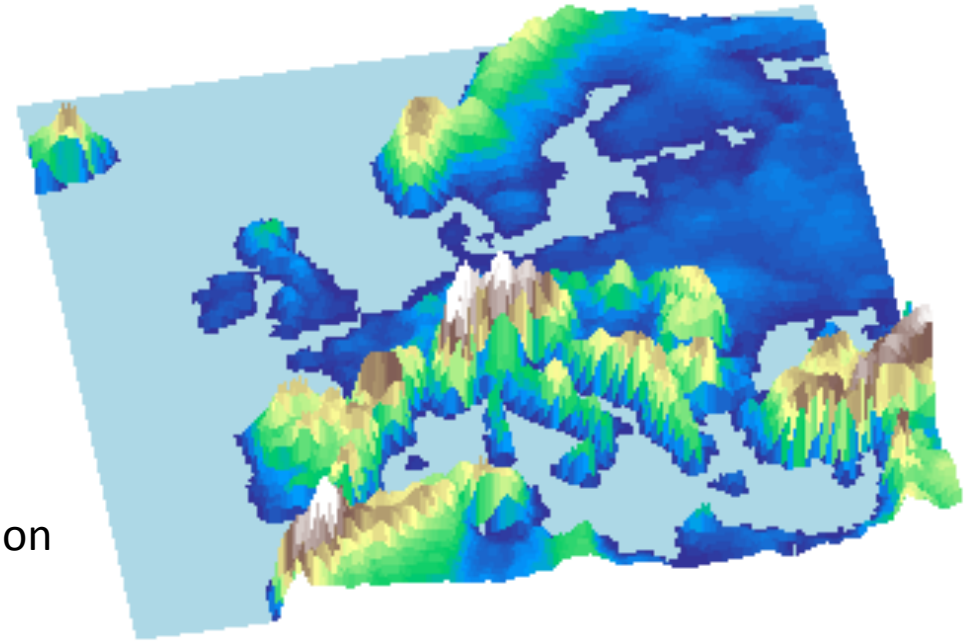


Illustration of the orographic representation at standard and high resolution over Europe in a global model.
Orographic processes are highly non-linear



25km resolution orography

Examples of impact of resolution on climate processes in individual models

- Large-scale moisture transports
- Severe storms over Europe
- Tropical cyclone intensity
- ENSO predictability
- Blocking and orography
- Weather regimes and stochastic processes
- SST mean state and variability
- SST biases and Euro-Atlantic blocking
- Mid-latitude jet position in aquaplanet

Project Athena: Euro-Atlantic blocking and resolution
The role of mountains is key.

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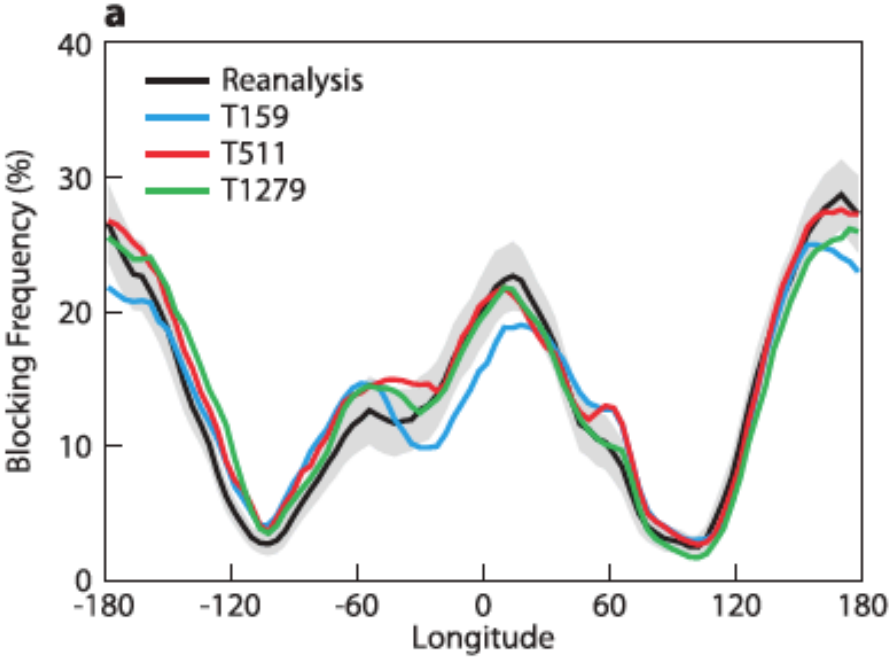
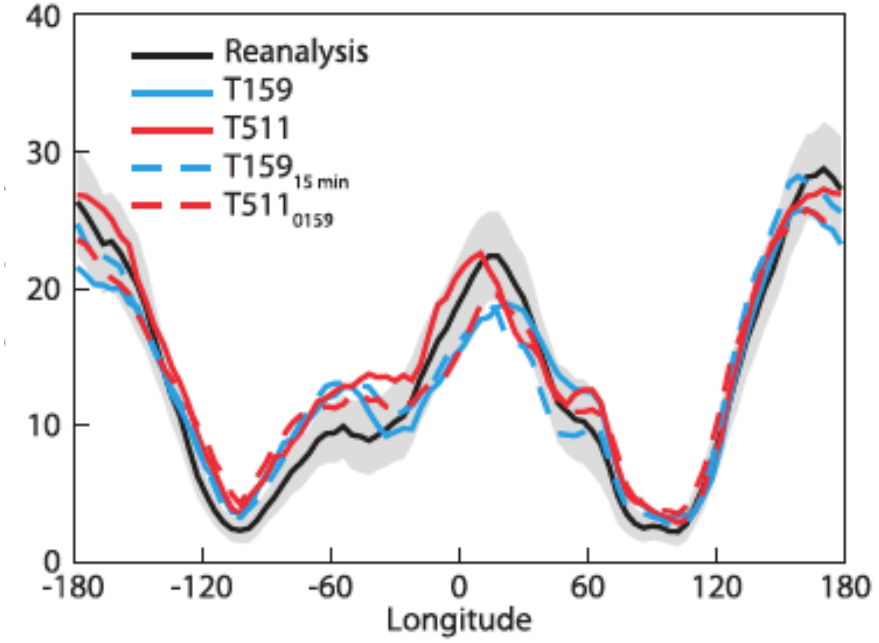
Equally, Jung et al. (2014), Geophys. Res Lett. argued that **small-scale atmospheric phenomena such as fronts, mesoscale cyclones, and topographic jets play an important role in driving the mean oceanic circulation** .
Representation of topography is also important.

Role of horizontal resolution



Role of topography



Jung et al. (2012), J. Climate

Modelling groups expressing interest in HighResMIP (at least for Tier 1 simulations)

Country	Group	Model
China	BCC	BCC-CSM2-HR
Brazil	INPE	BESM
China	Chinese Academy of Meteorological Sciences	CAMS-CSM
China	Institute of Atmospheric Physics, Chinese Academy of Sciences	FGOALS
USA	NCAR	CESM
China	Center for Earth System Scienec/Tsinghua University	CESS/THU
Italy	Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC
France	CNRM-CERFACS	CNRM
Europe	EC-Earth consortium (11 groups)	EC-Earth
USA	GFDL	GFDL
Russia	Institute of Numerical Mathematics	INM
Japan	AORI, University of Tokyo / JAMSTEC / National Institute for Environmental Studies	MIROC6-CGCM
Japan	AORI, University of Tokyo / JAMSTEC / National Institute for Environmental Studies	NICAM
Germany	Max Planck Institute for Meteorology (MPI-M)	MPI-ESM
Japan	Meteorological Research Institute	MRI-AGCM3.xS
UK	Met Office	UKESM / HadGEM3

European HighResMIP resolutions (as part of PRIMAVERA)

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Joint Weather and Climate

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

- Example resolutions which will definitely contribute to HighResMIP
- Concentrate on horizontal resolution – keep vertical resolution the same
- **ECMWF is an NWP partner – present day simulations, extra ensemble members – we welcome other NWP centres' submissions**

- AMIP-style
  - 1950-2050 (Prescribed SSTs, sea-ice, possibly aerosol)
  - Low and high resolutions, 60-100km and ~25km
  - Ensembles ~3
- Coupled AOIL
  - 1950-2050
  - Low and high resolutions, 60-100km and ~25km atmosphere and ocean
  - Fixed 1950's forcing (CTL) vs all forcings (transient) (RCP4.5/8.5)
  - Ensembles ~3

HighResMIP model configurations (1)

- Parallel standard and high resolution integrations
  - **STD likely to be default CMIP5/CMIP6-DECK resolution (~100km atmosphere resolution)**
  - Hence DECK is benchmark for STD, HI is sensitivity test
  - **HI being ~25km atmosphere resolution**
- **Strongly encourage absolutely minimal differences between STD and HI configurations**
  - Vital part of HighResMIP is to look for systematic differences with model resolution across multi-model ensemble
  - If extra tuning is made between different resolutions, it will make it extremely hard to pick apart the causes of differences
  - NOT a beauty contest to have the perfect HI model, we are most interested in the delta between resolutions
- **Similarly vertical resolution should be the same in STD and HI**

HighResMIP model configurations (2)

- Diagnostics list
  - Currently finishing initial submission to CMIP6 for HighResMIP diagnostic list (having attempted to consult widely on required diagnostics)
  - Considerable number of extra high frequency (1h, 3h, 6h) diagnostics compared to CMIP5 list, to look at extreme processes in particular
  - Balance between scientific interest and manageable data volumes

- Integration protocol (STD + HI)
  - Physical climate system only, minimal Earth System components
  - Tier 0: simple 1950-2050 forced-atmosphere integrations using SST and sea-ice datasets to be provided
  - Tier 1: coupled simulations 1950-2050
  - Tier 2: extension of forced integration to 2100, Tier 3: Aquaplanet
  - Further discussions on more detailed aspects of protocol are ongoing, and will be published in GMD Special Issue later in 2015
  - Will also be published on HighResMIP wiki, together with helpful scripts for producing forcing datasets
  - Contacts: haarsma@knmi.nl, malcolm.roberts@metoffice.gov.uk

Questions for WGNE on HighResMIP protocol

- Prescribed SST and sea-ice (AMIP-style) integrations
  - Best methods to produce a continuous 1950-2050 forcing set?
  - Seamlessly matching the observed record (to 2014) with anomalies from CMIP5 (from 2015)
  - Can partly use Mizuta et al methodology, but are there techniques to match up decadal variability across observed/projected time boundary
  - Understand that some groups prefer to use slab-ocean rather than fixed SST, but we need a standard protocol for all to follow.
- Prescribed aerosol concentrations
  - Would like all participating models to use similar aerosol concentrations (rather than emissions) to be more comparable, to be produced by RFMIP
  - Is this likely to be possible – different models have very different aerosol schemes and climatologies, different tuning needed conpared to standard model
- Coupled models
  - Ocean spinup techniques that do not involve 100's years of integration
  - Suggestions so far include:
    - interpolation from lower resolution model to reduce cost,
    - use shorter spinup as used in decadal forecasting (fixed atmosphere forcing for period of interest, e.g. 1950 here) until TOA within some bounds.
    - Coupled model will be run as pair of fixed CTL forcing (1950) and transient forcing, hence any residual drift can be subtracted
    - Use EN4 ocean analysis for 1950 start point
- Any other advice on experimental design and protocol to answer questions about impact of model resolution on representation of climate processes

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