WP1 Development and application of metrics for process-based evaluation and projections

Breakout group session

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- Attendants: Francisco Doblas-Reyes (BSC), Javier Vegas (BSC), Reinhard Schiemann (NCAS), Alex Baker (NCAS), Irene Mavilia (CNR), Ramón Fuentes Franco (SMHI), Christiane Jablonowski (Univ. Michigan)
- Science issues:
  - What are the dependencies around these issues?
  - Priorities of these issues?
  - How will they be resolved?
  - Will the scientific content deviate from the plan?
- Technical issues: How do simulation delays affect this WP?
  - What are the dependencies around these issues?
  - Priorities of these issues?
  - How will they be resolved?
  - Will the scientific content deviate from the plan?
- Timescales
- External science interactions: papers, conferences, releases
- Deliverables and milestones

Breakout group session

- Science issues:
  - Observational uncertainty: multiple reanalyses, ensemble reanalyses, propagation of uncertainty
  - Organisation of the metric development: solving redundancies (modes of variability, global budgets, blocking with 1D, 2D or tracking); how did WP2 solve it? Open tickets? Compare methods
  - What is the metric? Pattern correlation or RMS, include an uncertainty measure, decide if it's a number or a story (process based); open a ticket
  - Interpolation uncertainty: buid into the total uncertainty, take advantage of the new ESMVal backend
  - Interest in extremes (NCAS); check with the CORDEX community
- Technical issues: How do simulation delays affect this WP?
  - ESMVal is the framework to plug in the functions; use PRIMAVERA svn
  - Build on WP2 data structure and shared space on Jasmin; check if there's anything missing for WP1 stuff
  - How much effort to put into the pre-PRIMAVERA simulations instead of waiting for the Stream 1 simulations? Important for early-career scientists that need to publish; a knock-on effect of the delay of the simulations
  - Create a prototype of metric that can be included in ESMVal to use as documentation for all the other developments; Javi to prepare a set of basic rules to follow when developing, illustrate it with David's example in a ticket
  - Prepare and test functions without waiting for them to be integrated in the ESMVal tool
- Timescales
  - Prototype of metric should be available in April 2017; ESMVal backend rewrite starts in Feb 2017
  - Need to set a deadline (February) to decide which datasets are still needed in Jasmin beyond what WP2 has already done to make them available in Jasmin before April
  - No delays foreseen for the development of the metrics planned
  - All WP1 partners to double check if the WP9 variable list contains the variables required by the metrics planned asap before the simulations start
- External science interactions: papers, conferences, releases
  - CORDEX, mainly for extremes and soil processes
  - CLIVAR, e.g. Walter Robinson (NCSU) for blocking and diabatic processes, DCVP
  - NCAR's CVDP
  - Duane Waliser's tool (RCMS) that runs on the ESGF nodes https://rcmes.jpl.nasa.gov/content/overview
  - WGNE's systematic error workshop (spring, Canada)
  - Joint PRIMAVERA meeting at AGU 2017 or EGU 2018
  - Paper on blocking assessment in Stream 1 models (Reinhard), try to involve CNR, CMCC
  - SMHI paper on impact on sea ice, probably coordinated with other partners
  - CNR with Univ Oxford on impact of resolution and stochastic parameterisations on weather regions and teleconnections
  - NCAS on precipitation extremes in the pre-PRIMAVERA ensemble
- Deliverables and milestones

Catalogue of PRIMAVERA metrics

- A survey was launched within the WP1 partnership aimed at defining a “Catalogue of PRIMAVERA metrics”
- Two sets of metrics identified, to be developed in two stages: high (Year 1) and low (Year 2) priority
- Metrics organised by climate component plus a "coupled" set accounting for those metrics explicitly designed to quantify the coupling between different climate constituents (land-atmosphere coupling, air-sea interaction, etc.)

Catalogue of PRIMAVERA metrics

- The vast majority of the suggested metrics are **distinctively process-oriented**, an aspect well received by all partners, enhancing the complementarity of PRIMAVERA metrics with other similar ongoing metrics development initiatives
- Contrary to initial concerns, there is **little redundancy** in the metrics. Redundancies (e.g., atmospheric blocking) are usually approached with alternative methodologies, providing a **wide spectrum of possible options**
- **Joint discussions and dialogue with WP2 community** around specific topics, favoured the metrics development process
- The WP1 metrics will allow a comprehensive and innovative **anatomy of the PRIMAVERA/HighResMIP simulations**. The table is not closed, rather the beginning of a process where partners are invited to add new metrics to complete the table

WP1 Development and application of metrics for process-based evaluation and projections

Summary breakout group

Francisco Doblas-Reyes (BSC)
Alessio Bellucci (CMCC)

Catalogue of PRIMAVERA metrics

Preliminary catalogue of PRIMAVERA metrics (WP1)

Partner	Partner ID	Contact persons for metrics development
CERFACS	1	Julien Boe (boe@cerfacs.fr)
CMCC	2	Panos Athanasiadis, Enrico Scoccimarro (panos.athanasiadis@cmcc.it, enrico.scoccimarro@ingv.it), Alessio Bellucci
CNR	3	Irene Mavilia (i.mavilia@isac.cnr.it), Susanna Corti, Chiara Cagnazzo
KNMI	4	Rein Haarsma (rein.haarsma@knmi.nl), Klaver Remko
MetOffice	5	Laura Jackson (laura.jackson@metoffice.gov.uk), Malcolm Roberts, Keith Williams, Thomas Voigt (*AutoAssess*)
MPI-M	6	Dian Putrasahan (dian.putrasahan@mpimet.mpg.de), Katja Lohmann (katja.lohmann@mpimet.mpg.de)
SMHI	7	Grigory Nikulin, Torben Koenigk (grigory.nikulin@smhi.se, torben.koenigk@smhi.se)
UCL-BSC	8	Francois Massonnet (francois.massonnet@bsc.fr), David Docquier
UREAD	9	Reinhard Schiemann (r.k.schiemann@reading.ac.uk)
BSC	10	Louis-Philippe Caron (louis-philippe.caron@bsc.es), Eleftheria Exarchou (eleftheria.exarchou@bsc.es), Neven Fuckar (neven.fuckar@bsc.es)

Table 1: WP1 contributing partners (c1), corresponding ID (c2) and contact persons (c3).

ATMOSPHERE and LAND			
Metric [Partner ID]	**Metric description**	**Observational Reference**	**Software (language used/shareable or not/part of a package)**
High Priority Metrics (approx. Nov 2016)			
Baroclinicity [1]	Estimation of the Eady Growth Rate (EGR) parameter at monthly timescale, integrated from near surface to 500 hPa pressure level.	Monthly (or daily) temperature, wind and geopotential height from atmospheric reanalysis. Several reanalysis dataset are recommendable (NCEP/ERAI/ERA20C)	NCL, shareable
Storminess [2]	Square-root of the squared high-pass (10-day cut-off) meridional wind anomaly at 300 hPa, $(v'v')^{1/2}$. Its mean and its variance (Athanasiadis et al., 2010)	ERA-Interim	Python, shareable, stand-alone
Jet Latitude [2+3]	Latitude of maximum in the meridional profile of low-level zonal wind in the N. Atlantic (0-60W). Its distribution and relation to the NAO and EA pattern (Woollings et al., 2010).	ERA-Interim	Python, shareable, stand-alone
E-vectors [2+9]	E-vector components (3D) as in Hoskins et al. (1983) computed for synoptic high-frequency eddies	ERA-Interim	Python, shareable, stand-alone (collaboration with UREAD)
Blocking 2D [2+3]	2D-distribution of atmospheric blocking as in Scherrer et al. (2006)	ERA-Interim	Python, shareable, stand-alone (collaboration with CNR)
Blocking 2D [9]	2D index (AGP, Scherrer el al., 2006) for the Northern Hemisphere and selected regions as used in Schiemann et al., submitted.	ERA-40, ERA-Interim	R, shareable
Blocking 1D [2+3]	1D-distribution of atmospheric blocking as in Athanasiadis et al. (2014), or Davini et al. (2012)	ERA-Interim	Python, shareable, stand-alone (collaboration with CNR)
Extratropical cyclones, tropical cyclones [5+9+10]	Genesis, track and lysis density (e.g., Hoskins and Hodges, 2002) Storm number/intensity, Accumulated Cyclone Energy (ACE).	Several reanalyses IBTrACS	C/Fortran/Java Trackers: 1) K. Hodges trackers 2) GFDL Vortex tracker 3) TStorms Software
Global energy and water budgets [9]	Global-mean, climatological-mean values of all energy and water budget components as in Demory et al. 2014	L'Ecuyer et al, 2015; Rodell et al, 2015	Python
Global energy charcteristics [4]	Global energy spectra and spectral energy budget (Augier and Lindborg 2013)	Nastrom, Gage (1985) doi: 10.1175/1520-0469	Python
Large-scale pattern representation [3]	RMS and pattern correlation between observed and modelled patterns of variability modes obtained through classification methods. [Examples: weather regimes in the North Atlantic and North Pacific regions, tropical and extratropical teleconnections, bidimensional blocking indices, Atlantic jet stream regimes, etc.]	ERA interim NCEP	t.b.d. (Python packages under development)
NAM/ NAO [7]	Timeseries, pattern, SST-regressions	ERA-interim	ESMVAL-tool
Low Priority Metrics (approx. Nov 2017)			
99p-90p precipitation [2]	difference between the 99^{th} and the 90^{th} percentile of daily precipitation (Scoccimarro et al. 2013)	GPCP or TRMM	Python
99p-90p temperature [2]	difference between the 99^{th} and the 90^{th} percentile of daily temperature (Scoccimarro et al. 2013)	MERRA or JRA-55 or ERA-INTERIM	Python
Stratosphere-troposphere coupling *(see also Table COUPLED)* [3]	Area-weighted spatial correlations of NAM/SAM patterns between models and reanalysis at different altitudes and in different phases of ENSO	ERA-Interim, NCEP	Python
Regional energy characteristics [7]	Energy spectra and spectral energy budget for the North Atlantic		Python
Windstorms over Europe [7]	Wind storms over Europe based on 3h- wind speed	MESAN	TBD
Climate indexes for Europe [7]	P and T- based indexes.	To be decided	ICCLIM
Snow extent [7]	NH snow extent, trend, annual cycle, variation	GlobSnow	Python, cdo, Fortran
SPI, SPEI [7]	Drought and wetness indexes for different European regions	ERA-interim	Fortran

Table 2: *Metrics for the atmosphere and land. Note: the "+" symbol is used to indicate collaborations between different partners.*

COUPLED			
Metric [Partner ID]	**Metric description**	**Observational Reference**	**Software (language used/shareable or not/part of a package)**
High Priority Metrics (approx. Nov 2016)			
Land-atmosphere coupling (mainly in summer) [1]	(i) Climatological evaporative fraction (ii) Correlation between downward radiation at surface and evapotranspiration (Boé and Terray, 2008) (iii) Correlation between soil moisture and evapotranspiration (Boé and Terray, 2014) (different tests will be conducted: interannual correlation versus decadal correlation, regression coefficient versus correlation coefficient, detrending or not etc. The different metrics will be compared.)	ERA-Interim/Land and other similar products at the regional scale in order to evaluate the uncertainties on the observational reference	NCL, shareable
Frontal region air-sea coupling coefficient/strength at small spatial scales [1]	Regression/correlation coefficient between small scale sea surface temperature and near surface wind speed patterns	Daily NOAA-OI SSTs at a resolution of 0.25° And Quickscat 10m winds at a 25 km resolution	NCL, shareable
Atmosphere-ocean coupling coefficient [5]	Gradient of scatter plot relation between mesoscale SST and wind stress anomalies over boundary currents (Chelton and Xie 2010, Bryan et al 2010), and temporal correlation of these spatial anomalies	Use various daily SST datasets (CCI SST, OI-SST, OAFlux) and windstress datasets (QuikScat, CCMP, OAFlux)	Python, shareable. Not part of package.
Heat conduction index (*see also SEA-ICE table*)[8]	A diagnostic to characterize the process of heat conduction from the ocean to the atmosphere through the sea ice/snow media. Person responsible for coding the diagnostic: F. Massonnet (BSC/UCL)	IceBridge	Python, shareable. Already coded but not formatted to work on all models.
Low Priority Metrics (approx. Nov 2017)			
Cloud-temperature interactions [1]	Correlation between cloud cover and surface temperature (Boé and Terray 2014) (different tests will be conducted: interannual correlation versus decadal correlation, regression coefficient versus correlation coefficient, detrending or not etc.)	-ISCCP for clouds and gridded temperature products for temperature. -Atmospheric reanalyses	NCL, shareable
Polar-NAO-linkage [7]	Linking Arctic sea ice to NAO: correlations between autumn ice and winter NAO and 1-lag winter correlations.	ERA-interim	Python, cdo
Oceanic heat transport/Sea-Ice interaction [8]	Impact of ocean heat transport integrated along different sections on sea ice (extent, thickness, volume, etc.)	An oceanic reanalysis, probably ORAS5.	Python, shareable
Stratosphere-troposphere coupling *(see also Table ATMOS.)* [3]	Area-weighted spatial correlations of NAM/SAM patterns between models and reanalysis at different altitudes and in different phases of ENSO	ERA-Interim, NCEP	Python
TC-induced SST cooling [2]	Integrated max SST cooling induced by TCs (considering SST one day after TC passage compared to the pre-storm SST)	HadISST2 + IBTracs	Python

Table 3: *Metrics focusing on coupled interactions between different components of the climate system (e.g., land/atmosphere, ocean/atmosphere, etc.).*

SEA-ICE			
Metric [Partner ID]	**Metric description**	**Observational Reference**	**Software (language used/shareable or not/part of a package)**
High Priority Metrics (approx. Nov 2016)			
Regional ice areas [7]	8 Arctic sub areas as defined in Koenigk et al. (2016). Calculate sea ice area, trend and variation.	OSISAF and/or OISST2	Python, cdo
Performance metrics [8]	Synthesizing metrics of performance (see Massonnet et al., 2011, http://www.the-cryosphere.net/5/687/2011/tc-5-687-2011.pdf). Person responsible for coding the diagnostic: F. Massonnet (BSC/UCL)	OSI-SAF for sea ice concentration Upward looking Sonars (ULS) for thickness (thickness observations not yet on Jasmin)	Python, shareable. NOTE: This set of scripts will also be sent to the ESMVal tool; Veronika Eyring was highly interested in using these performance metrics for sea ice in the evaluation toolbox.
sea ice drift - strength feedback [8]	A diagnostic characterizing the response of sea ice speed to thinning and changes in concentration over the past decades; similar to Olason & Notz, 2014, http://onlinelibrary.wiley.com/doi/10.1002/2014JC009897/abstract)	OSI-SAF, IABP (buoy), ULS (thickness)	Python, shareable. Already coded but not formatted to work on all models.
Pan-Arctic and regional sea-ice extent, thickness, volume and drift. [10]	Difference between long-term forced response in models and available analyses/observations. Difference between variability (in residuals after removal of long-term change) in models and analyses/obs.	HadISST, OSI-SAF, NSIDC, ESA	R, cdo, Python (shareable)
Heat conduction index (*see also COUPLED table*) [8]	A diagnostic to characterize the process of heat conduction from the ocean to the atmosphere through the sea ice/snow media.	IceBridge	Python, shareable. Already coded but not formatted to work on all models.
Low Priority Metrics (approx. Nov 2017)			
Open water formation efficiency [8]	Sea ice concentration decrease normalized by sea ice thickness decrease; a local measure of the radiative albedo feedback.	Yet to be identified. YOPP?	Python, shareable. Already coded but not formatted to work on all models.
Fram Strait ice export [7]	Ice transport across Fram Strait, trends, annual cycle	NSIDC	Python, cdo
Arctic sea ice modes [10]	RMS and pattern correlation between observed and modelled patterns of variability modes obtained through classification methods applied to sea ice thickness.		
Power dissipated by the wind in the ice [8]	A measure of the ability of a model to turn wind kinetic energy into sea ice kinetic energy.	Difficult to observe, but the diagnostic can explain model-to-model differences	Python, shareable. Already coded but not formatted to work on all models.

Table 4: *Metrics for the sea-ice.*

OCEAN			
Metric [Partner ID]	**Metric description**	**Observational Reference**	**Software (language used/shareable or not/part of a package)**
High Priority Metrics (approx. Nov 2016)			
Labrador Sea heat release [7]	Turbulent surface heat flux integrated over Labrador Sea convection area as index for deep convection (Brodeau and Koenigk 2015)	ERA-interim	Python, cdo
AMO [7]	Atlantic multidecadal oscillation, pattern, timeseries, energy spectrum	HadISST	ESMVAL-tool
AMV-AMOC relationship [3]	Lag of the maximum correlation between AMV and AMOC	HadISST	Python
Low Priority Metrics (approx. Nov 2017)			
Ocean circulation metrics [5]	AMOC, heat transports	Standard reference datasets of Atlantic AMOC and heat transport values e.g. Ganachaud and Wunsch (2003).	Python (hopefully as part of AutoAssess package)
Cumulative temperature transport [1]	Cumulative vertical integral of the Atlantic potential temperature transport at 26.5ºN and its decomposition into an overturning and gyre component (Msadek et al. 2013). To be compared to temperature and velocity biases along the 26.5ºN section.	RAPID for temperature transport WOA and HydroBase for potential temperature Ocean Reanalysis for velocity	NCL, shareable
Link MOC/MHT [1]	Regression of the 26.5ºN Atlantic MHT onto the MOC using zero net mass transport across the section (Johns et al. 2011, Msadek et al. 2013)	RAPID for MOC and MHT at 26.5ºN	NCL, shareable
Transports in the North Atlantic [6+5]	Overflows and Atlantic inflow across the Greenland-Scotland Ridge		Python, part of Ocean-Assess
Estimation of ocean processes and surface heat fluxes contributions to the SST tendency [1]	Simple model of multivariate linear regression to link SST tendency with the heat fluxes term and sea surface height (SSH)	ERSSTb for SSTs, surface heat fluxes from OAFLUX, SSH from AVISO It is recommendable to use also an estimate of mixed layer depth (de Boyer et Montegut, 2004)	NCL, shareable
DMV ("Deep Mixed Volume") [7]	Deep mixed volume in NA convection areas. Integrate mixed water over convection area and depth. Take only mixed water below a critical depth into account (1000m for Lab Sea, 725 for GIN-Sea) (Brodeau and Koenigk 2015)	?/ ARGO-floats but time series short and due to binary behaviour of convection very uncertain	Python, cdo
Ocean heat content [10]	Ocean heat content computed over boxes or as maps (including or excluding the mixed layer). RMS and pattern correlations between observed and modelled patterns	ORAS4	Python, CDFtools
Surface fronts [7]	Horizontal surface temperature gradients in North Atlantic. Track max gradients.	HadISST, ORAS4	Python, Fortran

Table 5: *Metrics for the ocean.*

WP1 breakout group session

- Attendants: Francisco Doblas-Reyes (BSC), Javier Vegas (BSC), Reinhard Schiemann (NCAS), Alex Baker (NCAS), Irene Mavilia (CNR), Ramón Fuentes Franco (SMHI), Christiane Jablonowski (Univ. Michigan)
- Science issues:
  - WP1 is expected to offer more than just one number, but rather metrics with uncertainty estimates that allow building narratives (process based) of why the models deviate from an observational reference (e.g. the global heat budget picture); a ticket will be opened to discuss the issue
  - Observational (multiple reanalyses, ensemble reanalyses, propagation of uncertainty) and interpolation (take advantage of the new ESMVal backend) uncertainties
  - Solving redundancies (modes of variability, global budgets, blocking with 1D, 2D or tracking); how did WP2 solve it? Open tickets? Compare methods
  - Interest in extremes (NCAS), learn from the CORDEX community
- Technical issues:
  - ESMVal is the framework to plug in the functions; partners to use PRIMAVERA svn
  - Build on WP2 data structure and shared space on Jasmin; check what is missing for WP1
  - How much effort to put into the pre-PRIMAVERA simulations instead of waiting for the Stream 1 simulations? Important for early-career scientists that need to publish; a knock-on effect of the delay of the simulations
  - Create a prototype of metric that can be included in ESMVal to use as documentation for all the other developments (D1.1); Javi and David to open ticket
  - Prepare and test functions without waiting for them to be integrated in ESMVal

WP1 breakout group session

- Timescales
  - Prototype of metric in April 2017; ESMVal backend rewrite starts in Feb 2017
  - Deadline (February) to decide which datasets are still needed in Jasmin beyond what WP2 has already done to make them available in Jasmin before April
  - No delays foreseen for the development of the metrics planned
  - All WP1 partners to double check if the WP9 variable list contains the variables required by the metrics planned before the simulations start
- External science interactions: papers, conferences, releases
  - CORDEX, mainly for extremes and soil processes
  - CLIVAR, e.g. Walter Robinson (NCSU) for blocking and diabatic processes, DCVP
  - NCAR's CVDP
  - Duane Waliser's tool (RCMS) that can run on the ESGF nodes https://rcmes.jpl.nasa.gov/content/overview
  - WGNE's systematic error workshop (June, Canada)
  - Joint PRIMAVERA meeting at AGU 2017 or EGU 2018
  - Paper on blocking assessment in Stream 1 models (Reinhard), involve CNR, CMCC
  - SMHI paper on impact on sea ice, probably coordinated with other partners
  - CNR with Univ Oxford on impact of resolution and stochastic parameterisations on weather regimes and teleconnections
  - NCAS on precipitation extremes in the pre-PRIMAVERA ensemble
- Deliverables and milestones