Land aspects :
A zoom on two sister european projects

WGSIP – 6 Nov. 2024
Constantin Ardilouze

Funded by
the European Union

CONFESS
Consistent representation of temporal variations of boundary forcings in reanalyses and seasonal forecasts

CERISE
CopERnIcus climate change Service Evolution - CERISE

Similarities of the two projects

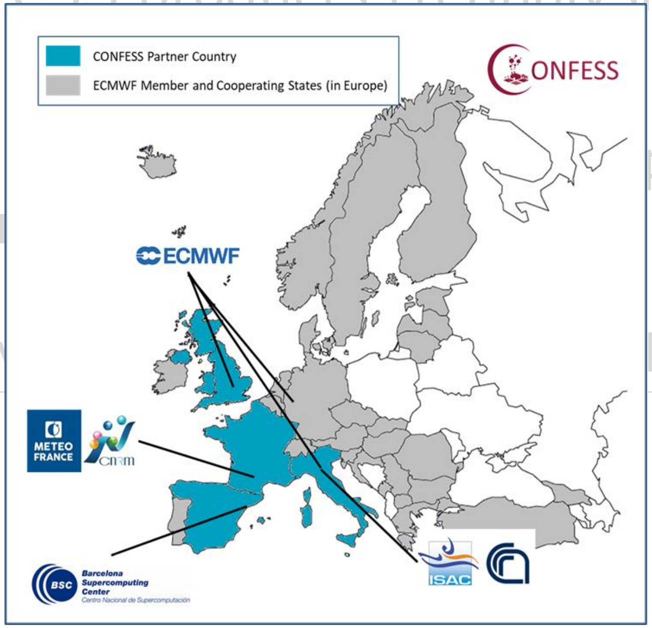
- Both projects aim to enhance the quality and reliability of C3S products (reanalysis and seasonal forecasts)
- Both have a strong focus on land aspects, and the incorporation of recent observational datasets
- Both are/have been coordinated by ECMWF

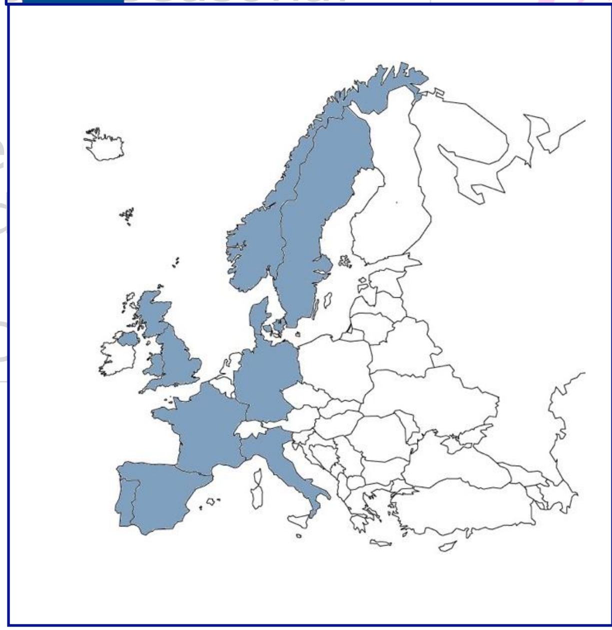
Differences

➢ Both projects aim to enhance the quali… nd reliability of C3S products (reanalysis a… seasonal forecasts)

➢ Both have a… pe… incorporatio… l c…

➢ Both are/ha… EC…





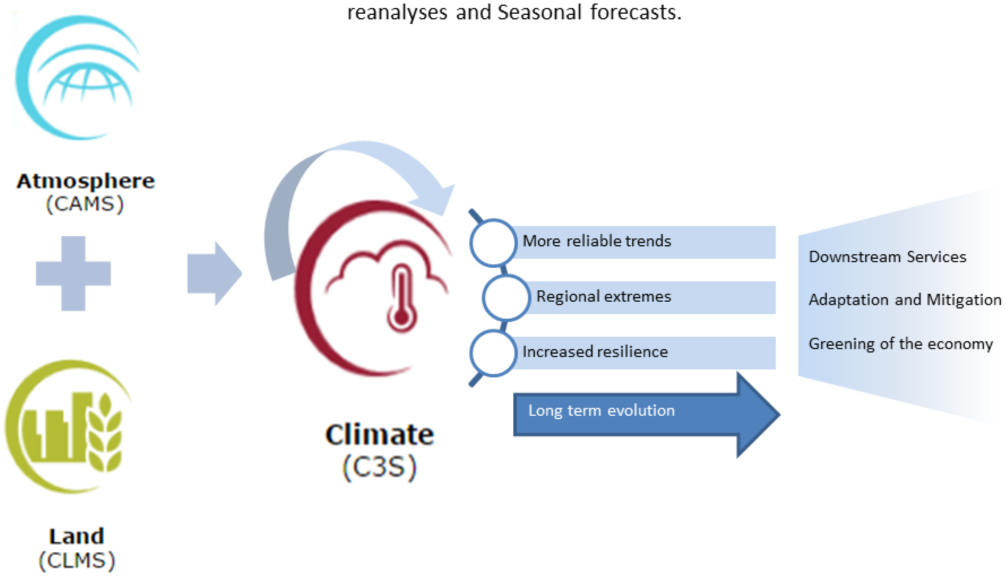
	CONFESS	CERISE
Timeline	2021-2024 (40 months)	2023-2026 (48 months)
Focus	Land boundary conditions	Land initial conditions
Size	~1M€ (4 partners)	~10M€ (12 partners)

CONFESS objectives

- **Representation of temporal variations of land cover and vegetation** in C3S systems by exploiting state of the art Copernicus observational datasets
- Improved temporal representation of tropospheric aerosols by harmonization of CMIP6 and CAMS datasets.
- Increased prognostic capabilities by inclusion of **prognostic vegetation** and response to volcanic and biomass burning emissions.

CONFESS

CONsistent representation of temporal variations of boundary Forcings in Earth System reanalyses and Seasonal forecasts.



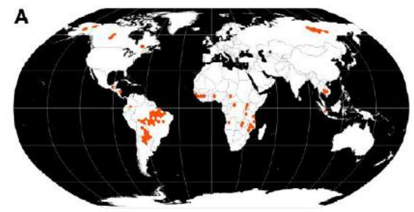
CONFESS : Initial motivation

- **Land-use / Land cover (LULC) maps** do not evolve with time in current reanalysis /seasonal forecast systems

- **LAI** : climatological seasonal cycle

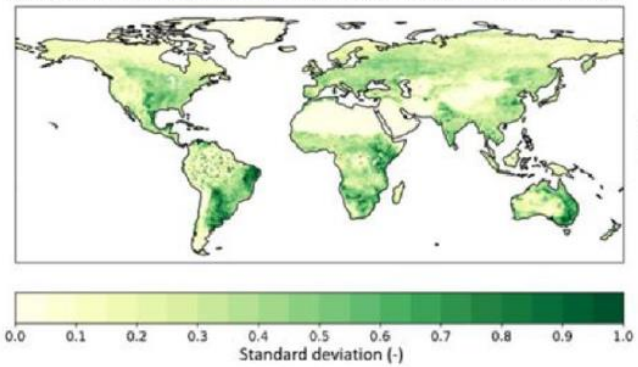
GLAD Global 2000-2020 LULC change

(high resolution dataset based on Modis and LandSat reprocessing, *Potapov et al 2022*



Deforestation hotspots

(a) Standard deviation of inter-annual LAI anomalies 1999-2019



CONFESS : datasets

- **Land-use / Land cover (LULC) maps** do not evolve with time in current reanalysis /seasonal forecast systems

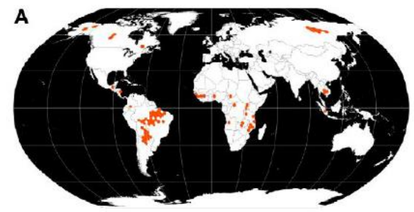
- **LAI** : climatological seasonal cycle

- **LULC datasets** : LUH2 (CMIP6) and ESA-CCI (harmonized satellite based dataset), at the yearly frequency, mapped onto model PFTs

- **LAI dataset** : products from different sensors hamonized by a CDF-matching technique

GLAD Global 2000-2020 LULC change

(high resolution dataset based on Modis and LandSat reprocessing, *Potapov et al 2022*



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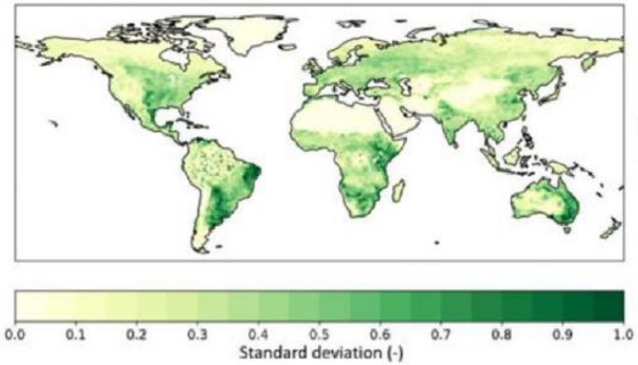

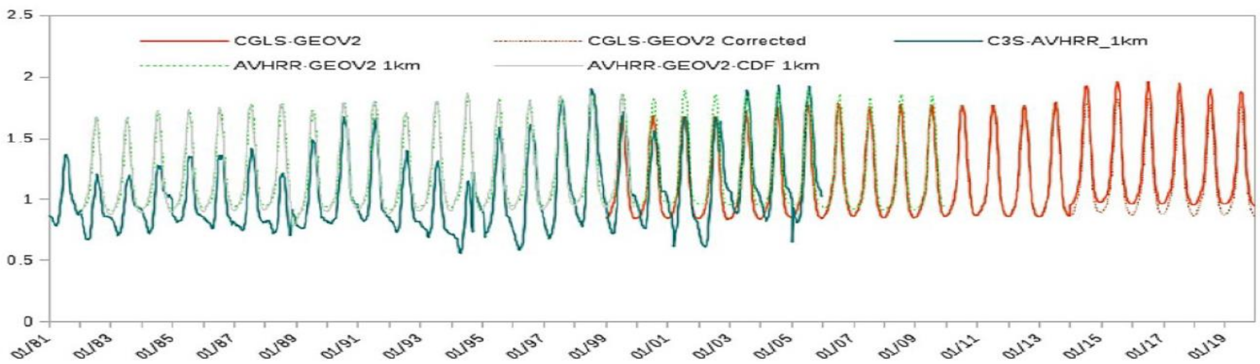

CONFESS : Experimental framework

Multi model experiments

- Control: LULC kept constant, LAI climatological
- Time-varying LAI (LULC is kept constant)
- Time-varying LAI and LULC

Multi year land-only simulations

- Evaluation of surface fluxes and soil moisture
- Provision of land initial conditions to seasonal hindcasts

Land ICs →

Seasonal hindcast integrations

- May and Nov starts, 50 to 100 members

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Land ICs →

Seasonal hindcast integrations

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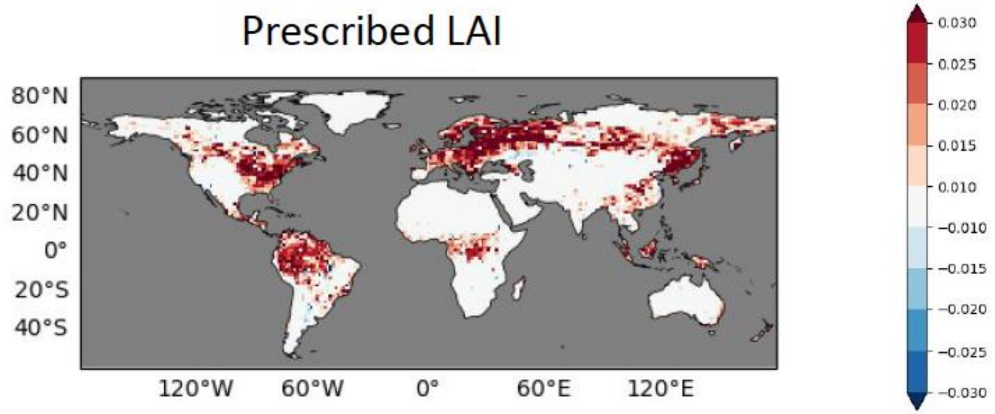
Single model experiments

- Prognostic Vegetation
- Comparison of different LAI climatologies
- Decadal hindcasts with time-varying LAI/LULC and improved Fcover parameterization

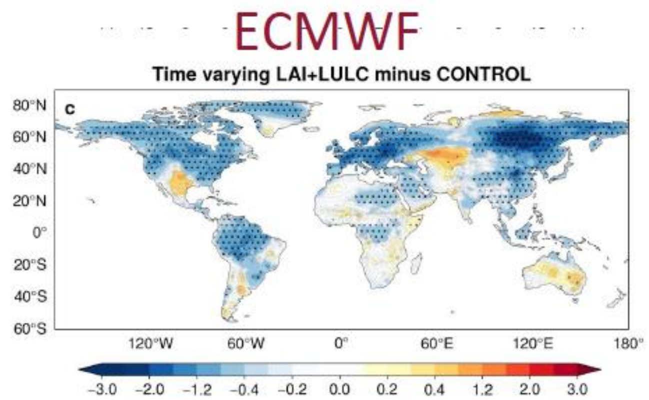
CONFESS : A few highlights (1)

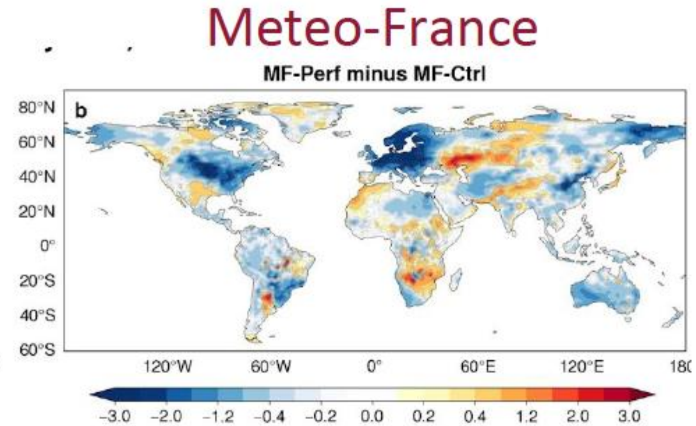
Impact of prescribing LAI on the t2m trend in seasonal hindcasts (JJA here)

LAI trend



Impact of LULC+LAI





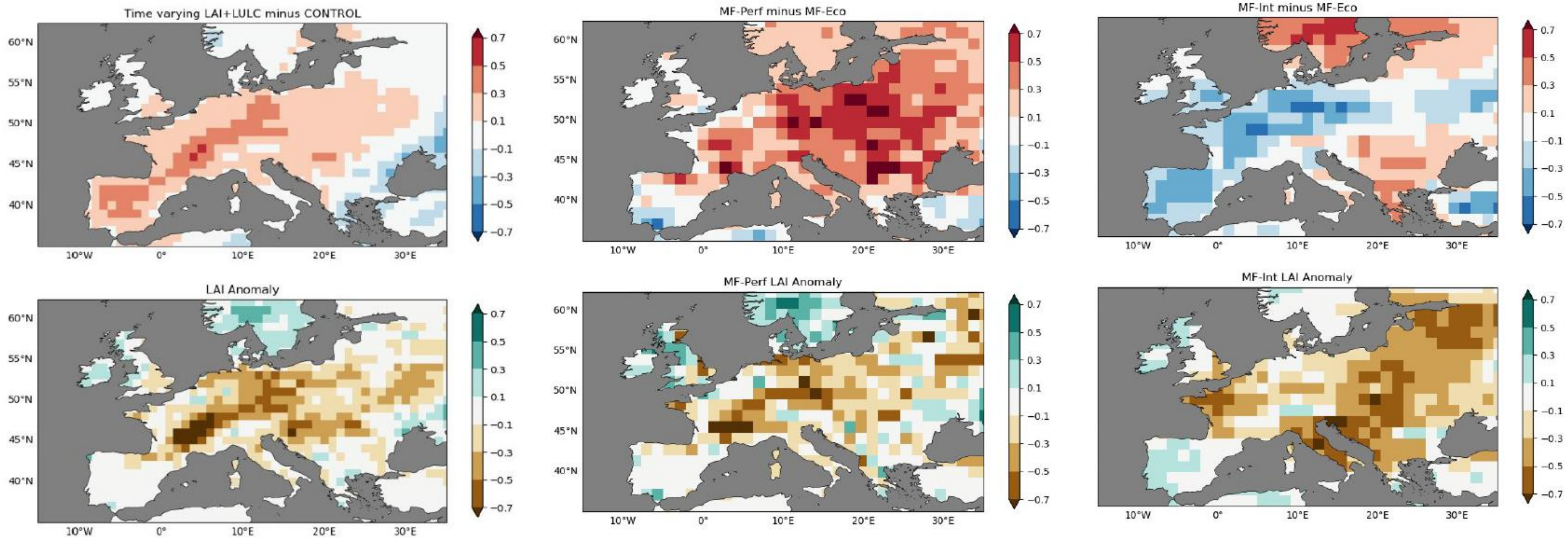
CONFESS : A few highlights (2)

European heat wave 2003: model comparison

ECMWF perfect LAI | MF perfect LAI | MF interactive LAI

T2m

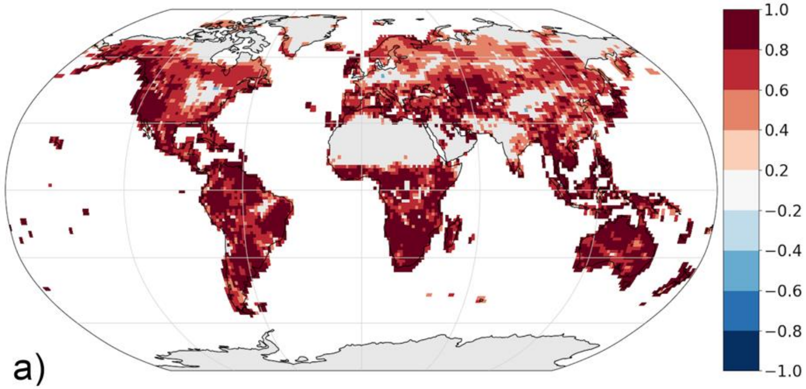
LAI

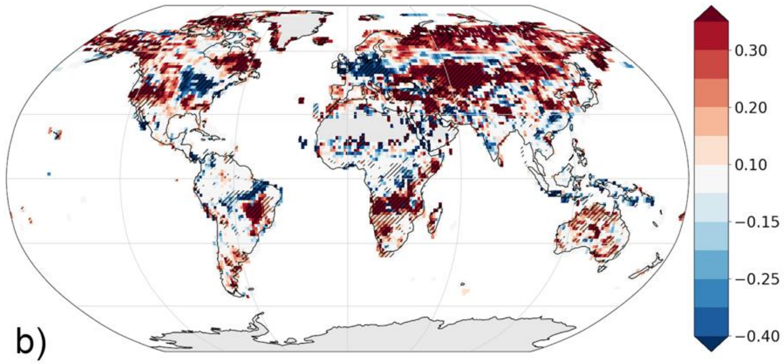


- Stronger T2m response of MF perfect LAI, worse response of MF interactive LAI
- Local differences in perfect LAI between ECMWF and MF : due to coarsening

CONFESS : A few highlights (3)

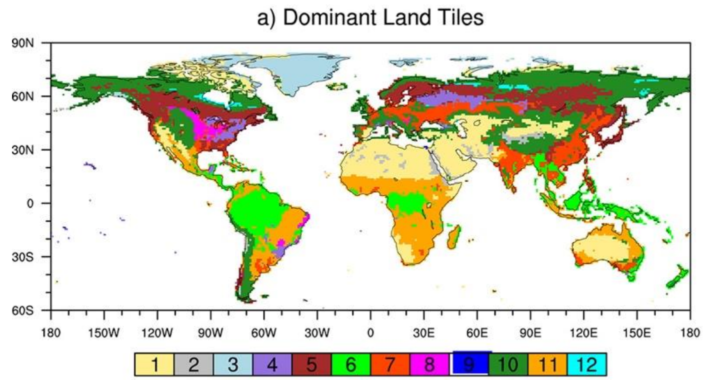
Seasonal Forecast of the Leaf Area Index (Perfect model)





June-July-August LAI anomaly correlation of the dynamical re-forecast with *prognostic LAI*

Difference of anomaly correlation with a persistence forecast.



CONFESS : results in a nutshell

- New time-varying LAI-LUC data sets implemented in models

- Impact on seasonal forecast skill, trends and extremes evaluated & quantified:

- Time varying LULC : little impact on forecast skill, but sizable impact (~10-20%) on the representation of trends, with strong seasonality.

- Time varying vegetation (both prognostic and prescribed) : larger impact on seasonal forecast skill of T2m, but the impact is not robust across systems, varying largely on location and sign.

- Increases the amplitude of heat extremes in specific cases

- The choice of LAI climatology has a sizeable impact on forecast skill of T2m.

CONFESS : recommendations

- CONFESS developments not fully ready yet for operational implementation in reanalyses and seasonal forecasts (but updated LULC and LAI climatologies in forthcoming IFS cycles)
- LULC: convergence needed between reanalysis and climate communities (for the well-observed overlapping period)
- LAI should be represented by a prognostic vegetation model, rather than a boundary condition. Initialization methods yet to be developed (cf. CERISE)
- Temporal records of LAI require further harmonization and uncertainty estimation
- Need to better quantify/verify soil moisture vegetation feedbacks at different time scales (thermodynamic effects, possible impact on the atmospheric circulation). And better parameterization of effective vegetation cover

CERISE objectives

- Develop new **coupled land-atmosphere data assimilation approaches**, including innovative work on observation operators using AI to optimize data fusion

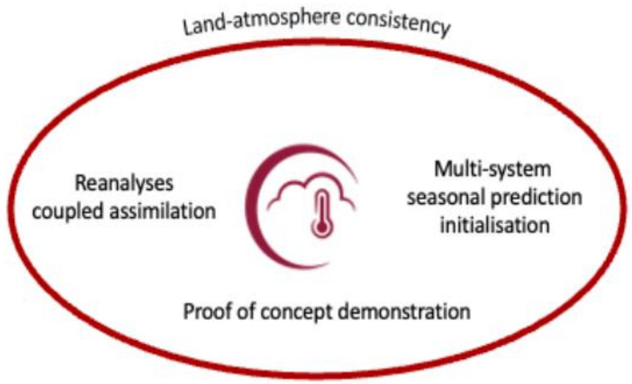
- Improve **land initialization strategies** for the next generations of the C3S reanalysis and seasonal prediction systems.

- Enhance the **exploitation of Earth system observations over land surfaces**, including from the Copernicus Sentinels and from the European Space Agency Earth Explorer missions, moving towards an all-sky and all-surface approach.

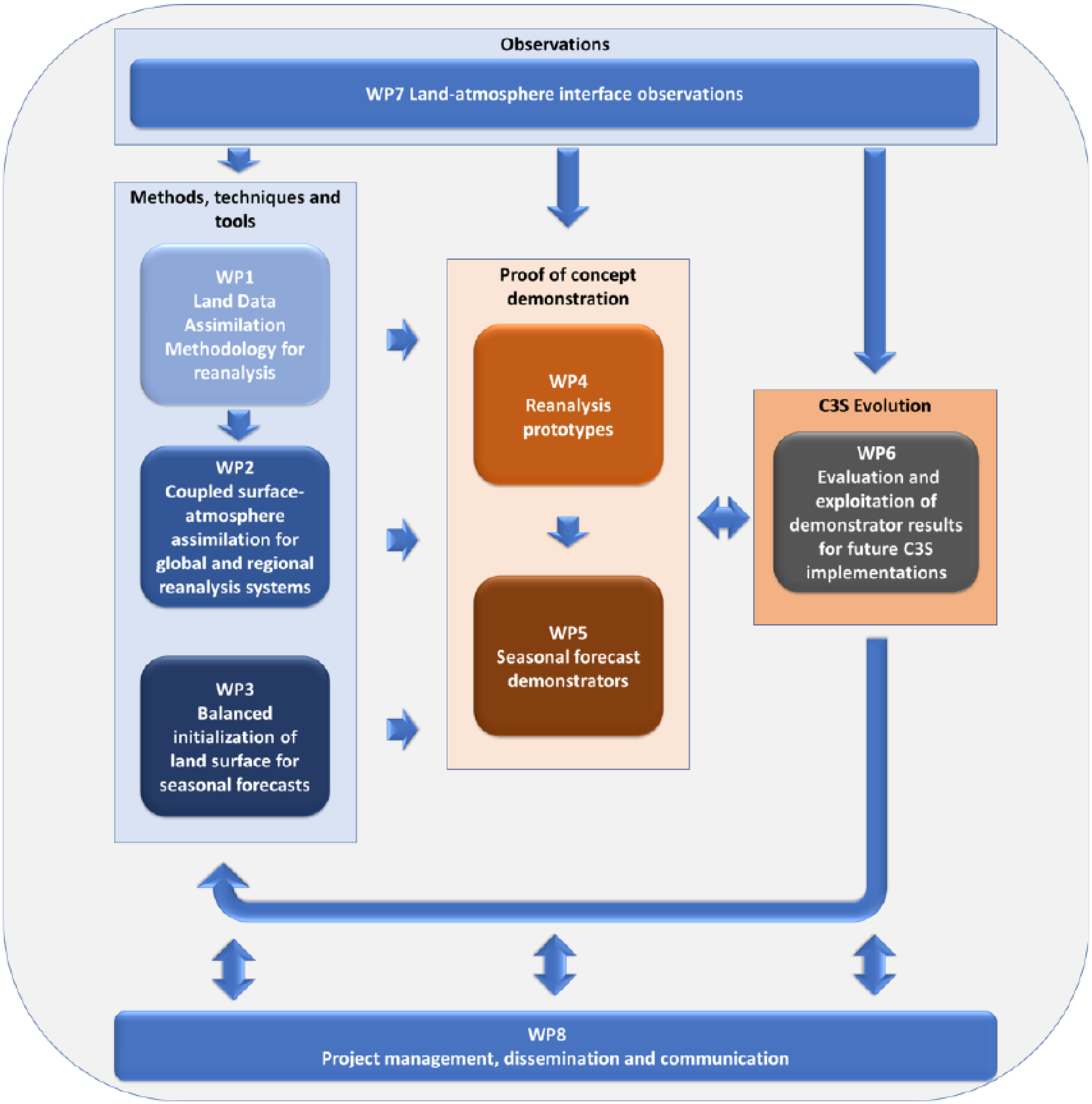
- Develop diagnostic tools and **prediction skill metrics that include integrated hydrological variables**

- Deliver proof-of-concept **prototypes and demonstrators**, to assess the feasibility of the integration of the developed approaches in the operational C3S.

CopERnIcus climate change Service Evolution - CERISE

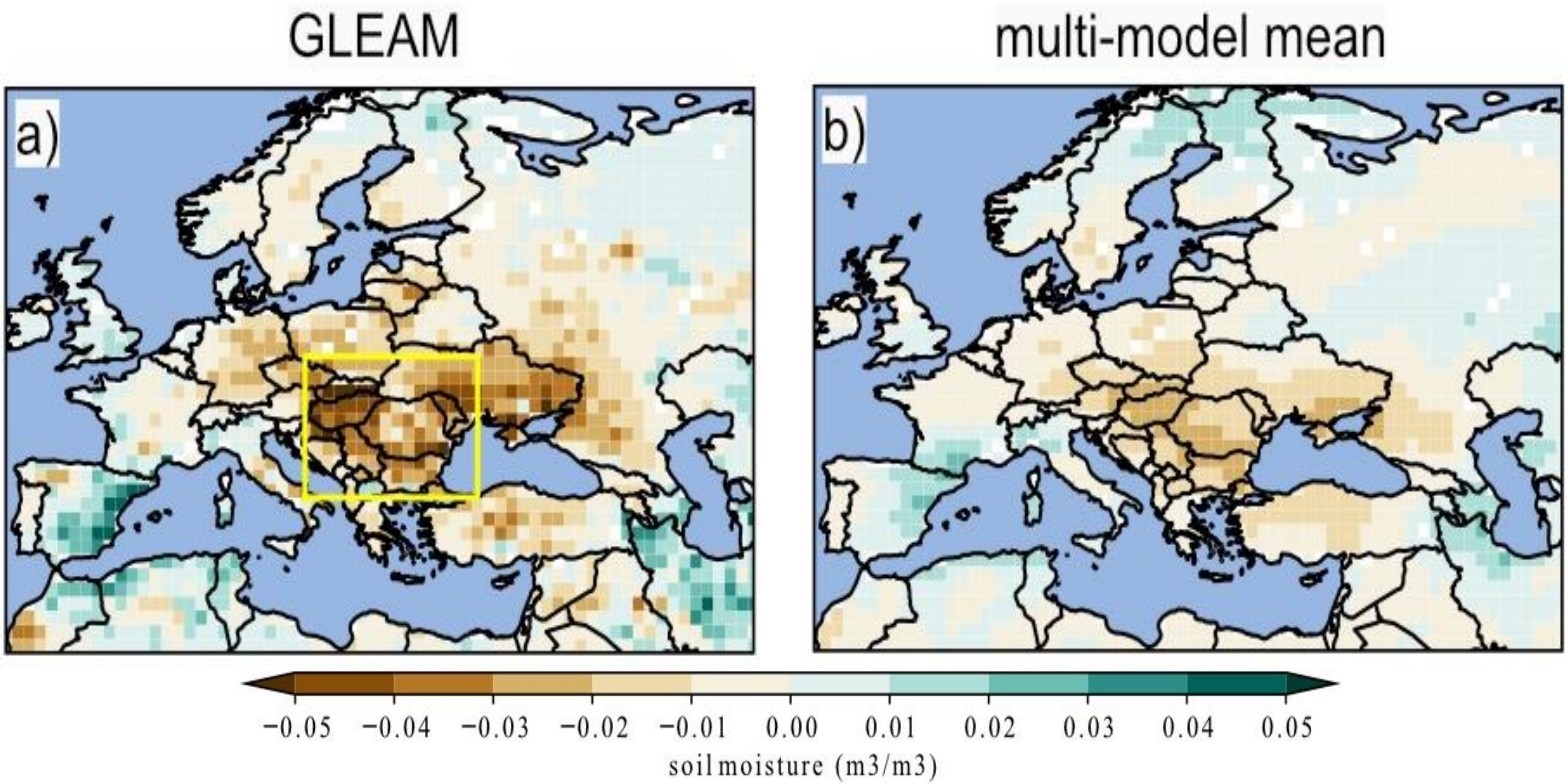


CERISE Work package structure



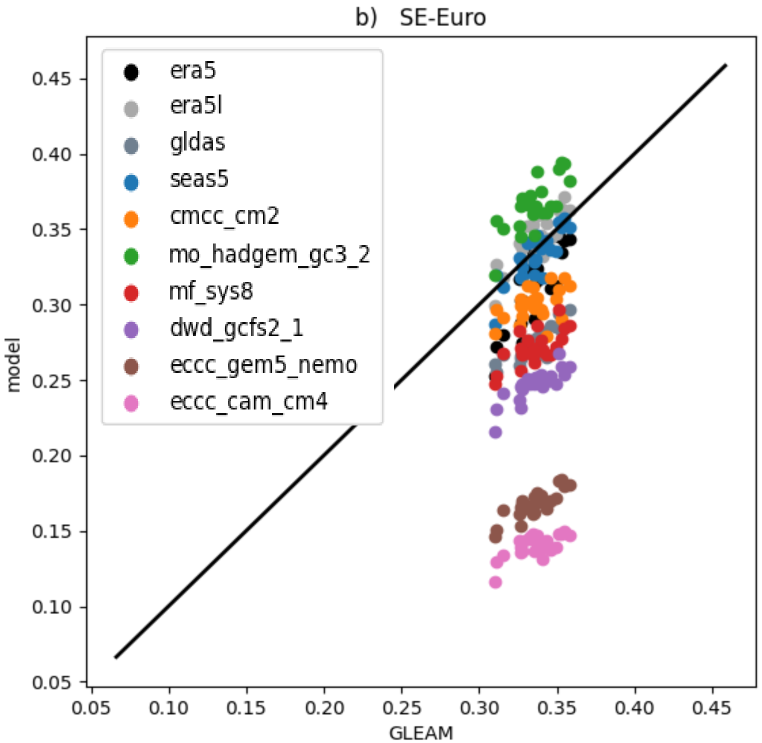
Evaluation of C3S initial conditions (1/2)

Composite of dry years minus wet years based on timeseries from yellow box.

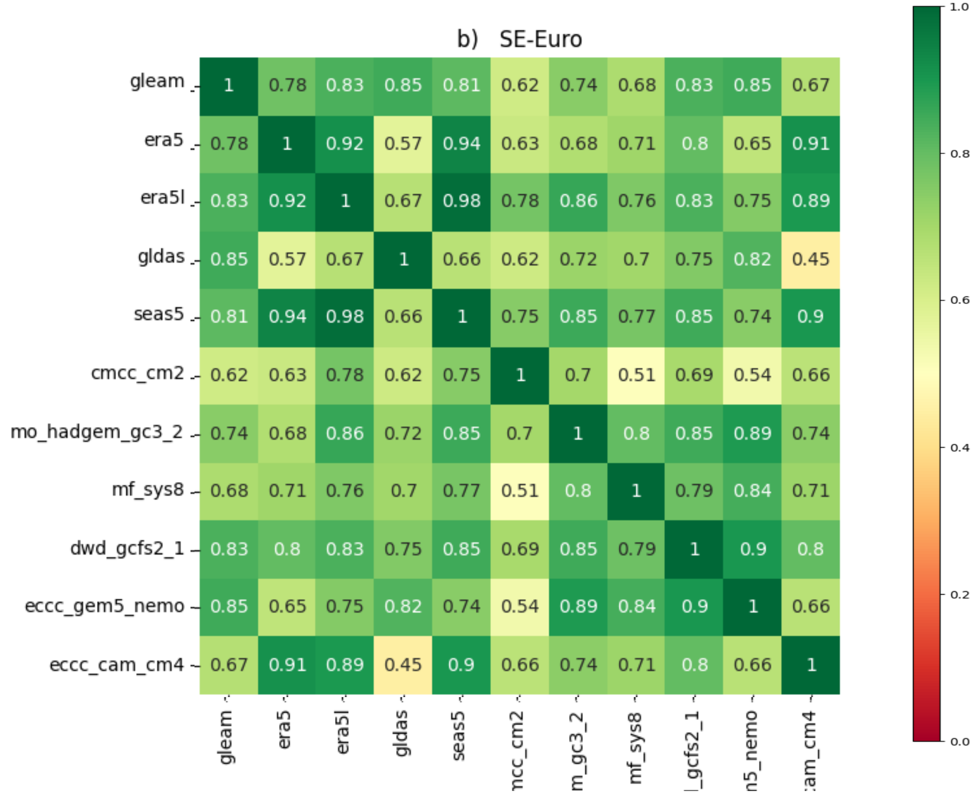


Credits: Jonathan Day (ECMWF)

Evaluation of C3S initial conditions (2/2)



Scatter plots of area averaged 1st May root-zone soil moisture



Correlation heatmaps of area averaged 1st May soil moisture between soil moisture analyses and C3S initial conditions

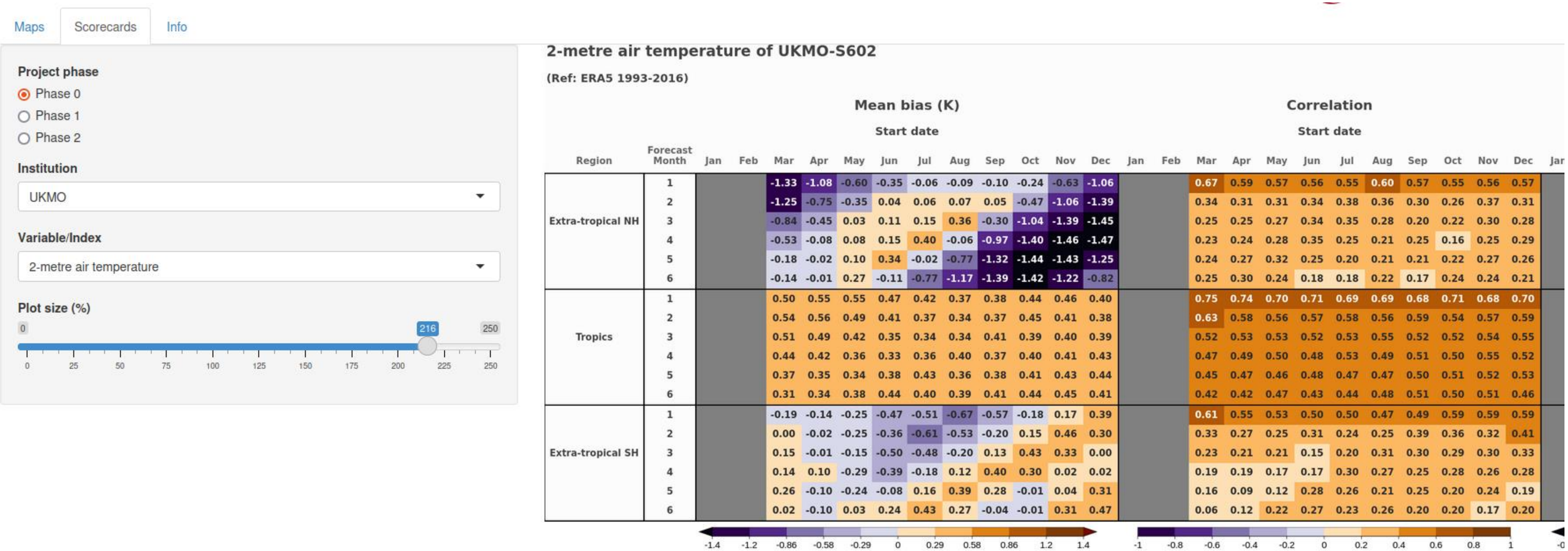
- ➢ A wide range of mean state but high inter-model correlations
- ➢ Large inter-model differences in soil moisture-evaporation coupling throughout summer months

To be submitted:

Soil-Moisture-Atmosphere Coupling Hotspots and Their Representation in Seasonal Forecasts of Boreal Summer

Jonathan Day (ECMWF), Frederic Vitart, Tim Stockdale, Patrica de Rosnay, Constantin Ardilouze, Daniele Peano, Kristina Fröhlich, Martin Andrews

CERISE: Scorecard tool



Mean bias (K) — Start date

Region	Forecast Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extra-tropical NH	1			-1.33	-1.08	-0.60	-0.35	-0.06	-0.09	-0.10	-0.24	-0.63	-1.06
	2			-1.25	-0.75	-0.35	0.04	0.06	0.07	0.05	-0.47	-1.06	-1.39
	3			-0.84	-0.45	0.03	0.11	0.15	0.36	-0.30	-1.04	-1.39	-1.45
	4			-0.53	-0.08	0.08	0.15	0.40	-0.06	-0.97	-1.40	-1.46	-1.47
	5			-0.18	-0.02	0.10	0.34	-0.02	-0.77	-1.32	-1.44	-1.43	-1.25
	6			-0.14	-0.01	0.27	-0.11	-0.77	-1.17	-1.39	-1.42	-1.22	-0.82
Tropics	1			0.50	0.55	0.55	0.47	0.42	0.37	0.38	0.44	0.46	0.40
	2			0.54	0.56	0.49	0.41	0.37	0.34	0.37	0.45	0.41	0.38
	3			0.51	0.49	0.42	0.35	0.34	0.34	0.41	0.39	0.40	0.39
	4			0.44	0.42	0.36	0.33	0.36	0.40	0.37	0.40	0.41	0.43
	5			0.37	0.35	0.34	0.38	0.43	0.36	0.38	0.41	0.43	0.44
	6			0.31	0.34	0.38	0.44	0.40	0.39	0.41	0.44	0.45	0.41
Extra-tropical SH	1			-0.19	-0.14	-0.25	-0.47	-0.51	-0.67	-0.57	-0.18	0.17	0.39
	2			0.00	-0.02	-0.25	-0.36	-0.61	-0.53	-0.20	0.15	0.46	0.30
	3			0.15	-0.01	-0.15	-0.50	-0.48	-0.20	0.13	0.43	0.33	0.00
	4			0.14	0.10	-0.29	-0.39	-0.18	0.12	0.40	0.30	0.02	0.02
	5			0.26	-0.10	-0.24	-0.08	0.16	0.39	0.28	-0.01	0.04	0.31
	6			0.02	-0.10	0.03	0.24	0.43	0.27	-0.04	-0.01	0.31	0.47

Correlation — Start date

Region	Forecast Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extra-tropical NH	1			0.67	0.59	0.57	0.56	0.55	0.60	0.57	0.55	0.56	0.57
	2			0.34	0.31	0.31	0.34	0.38	0.36	0.30	0.26	0.37	0.31
	3			0.25	0.25	0.27	0.34	0.35	0.28	0.20	0.22	0.30	0.28
	4			0.23	0.24	0.28	0.35	0.25	0.21	0.25	0.16	0.25	0.29
	5			0.24	0.27	0.32	0.25	0.20	0.21	0.21	0.22	0.27	0.26
	6			0.25	0.30	0.24	0.18	0.18	0.22	0.17	0.24	0.24	0.21
Tropics	1			0.75	0.74	0.70	0.71	0.69	0.69	0.68	0.71	0.68	0.70
	2			0.63	0.58	0.56	0.57	0.58	0.56	0.59	0.54	0.57	0.59
	3			0.52	0.53	0.53	0.52	0.53	0.55	0.52	0.52	0.54	0.55
	4			0.47	0.49	0.50	0.48	0.53	0.49	0.51	0.50	0.55	0.52
	5			0.45	0.47	0.46	0.48	0.47	0.47	0.50	0.51	0.52	0.53
	6			0.42	0.42	0.47	0.43	0.44	0.48	0.51	0.50	0.51	0.46
Extra-tropical SH	1			0.61	0.55	0.53	0.50	0.50	0.47	0.49	0.59	0.59	0.59
	2			0.33	0.27	0.25	0.31	0.24	0.25	0.39	0.36	0.32	0.41
	3			0.23	0.21	0.21	0.15	0.20	0.31	0.30	0.29	0.30	0.33
	4			0.19	0.19	0.17	0.17	0.30	0.27	0.25	0.28	0.26	0.28
	5			0.16	0.09	0.12	0.28	0.26	0.21	0.25	0.20	0.24	0.19
	6			0.06	0.12	0.22	0.27	0.23	0.26	0.20	0.20	0.17	0.20

- Developed by BSC (N. Perez-Zanon) in the context of CERISE

Questions ?

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