



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



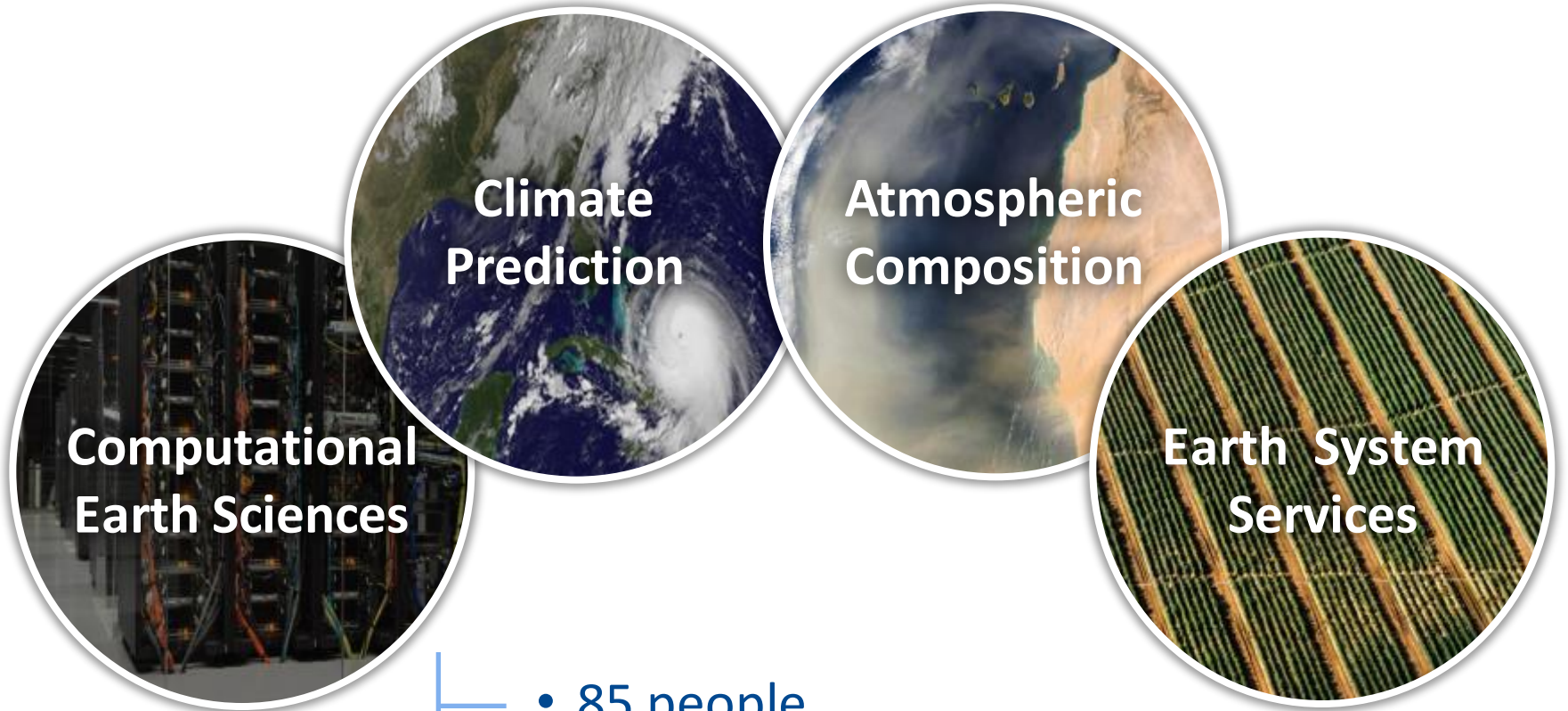
**EXCELENCIA
SEVERO
OCHOA**

El corazón partió: de la modelización del clima al desarrollo de servicios

Francisco J. Doblas-Reyes

BSC Earth Sciences Department

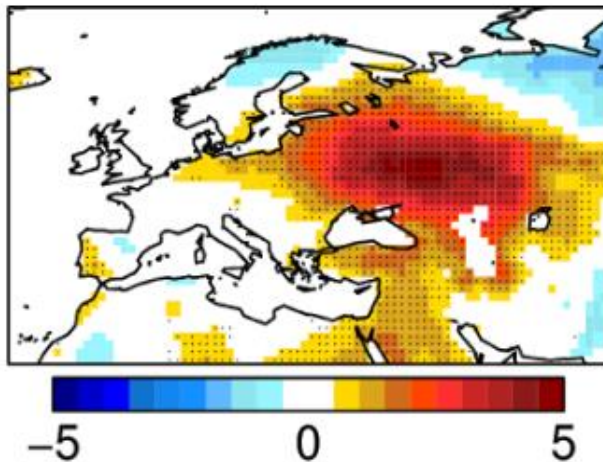
Environmental modelling and forecasting, with a particular focus on weather, climate and air quality



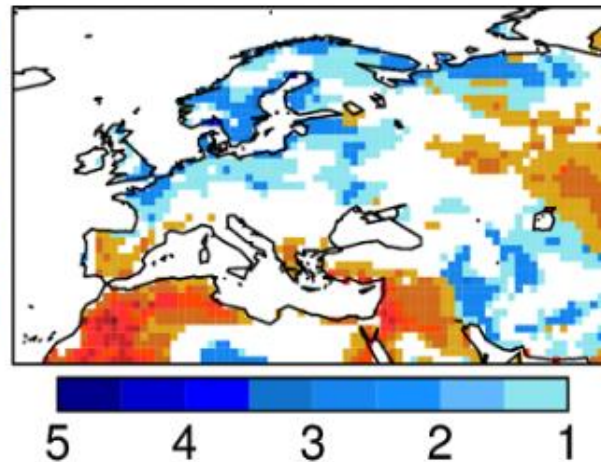
- 85 people
- H2020 projects, COPERNICUS and private contracts, ESA grants, national projects, ERC Consolidator Grant and AXA Chair

JJA near-surface temperature anomalies in 2010 from ERAInt (**left**) and odds ratio from experiments with a climatological (**centre**) and a realistic (**right**) land-surface initialisation for the upper quintile event. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.

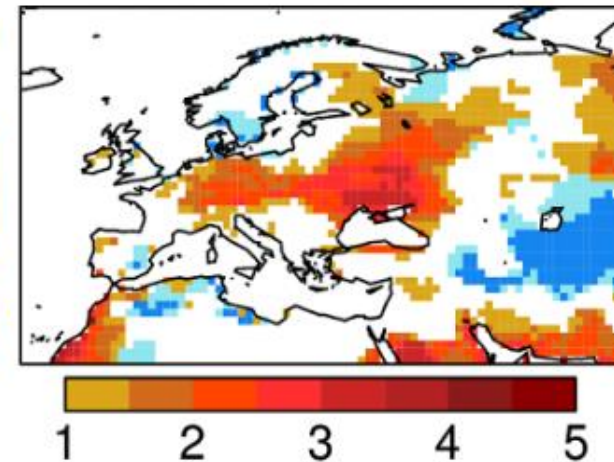
a) t2m: ERAInt



b) t2m: CLIM



c) t2m: INIT



The multi-model real-time decadal prediction exchange is a research exercise that guarantees equal ownership to the contributors.

BSC is one of the four centres recognised as global producers of decadal climate predictions by WMO-CCI.

Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

[The contributing prediction systems](#) are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

This work is supported by the European Commission SPECS project.

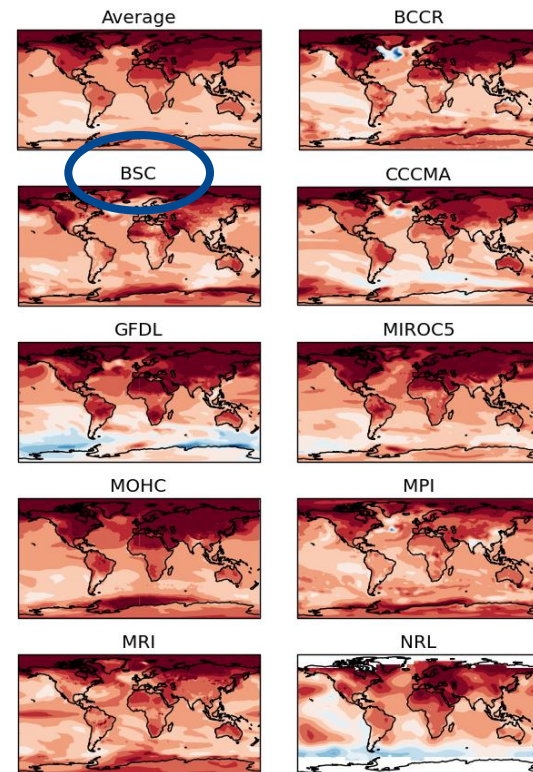


To learn more about decadal forecasts at the Met Office, see our current [decadal forecast](#).

Images last updated 2014-06-25

Issued: Period: Element:

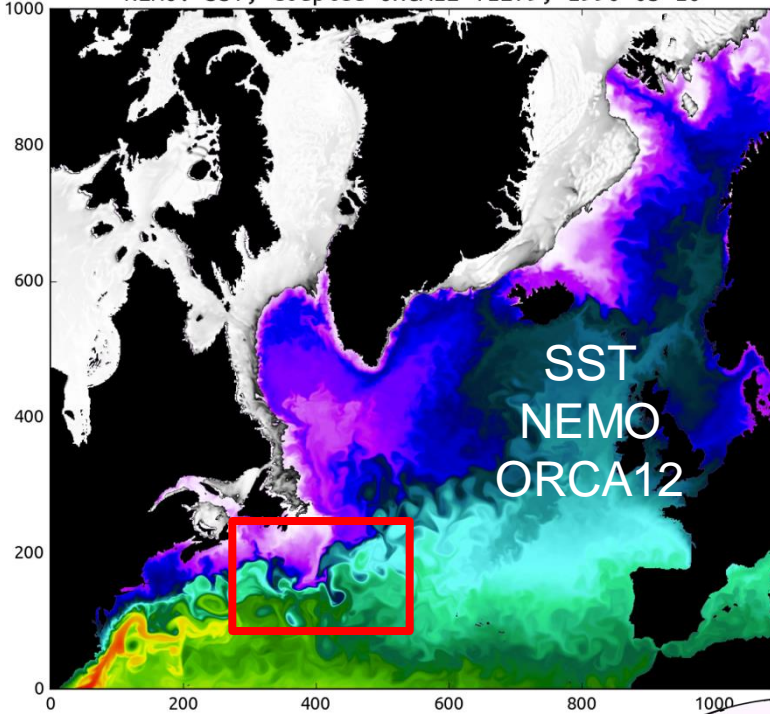
2017 predictions for 2018-2022 surface temperature



High-resolution global modelling

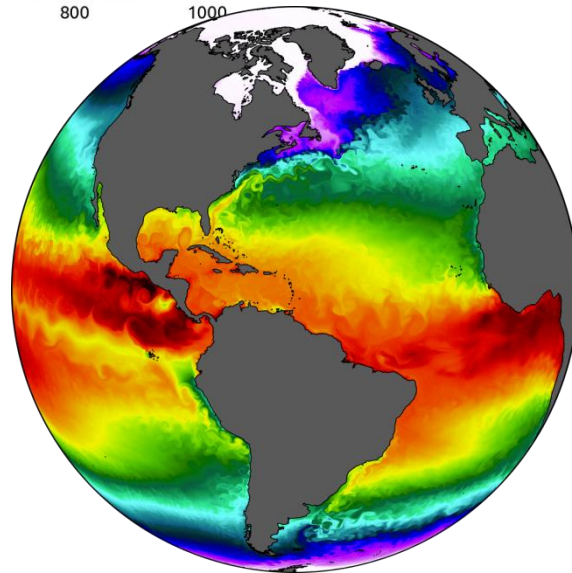
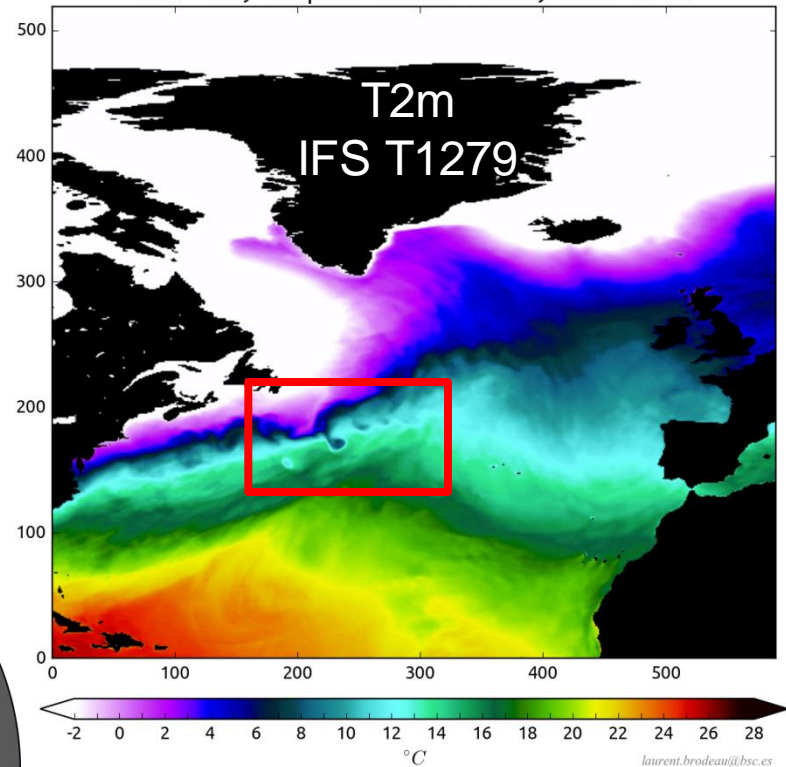


NEMO: SST, coupled ORCA12-T1279, 1990-03-10



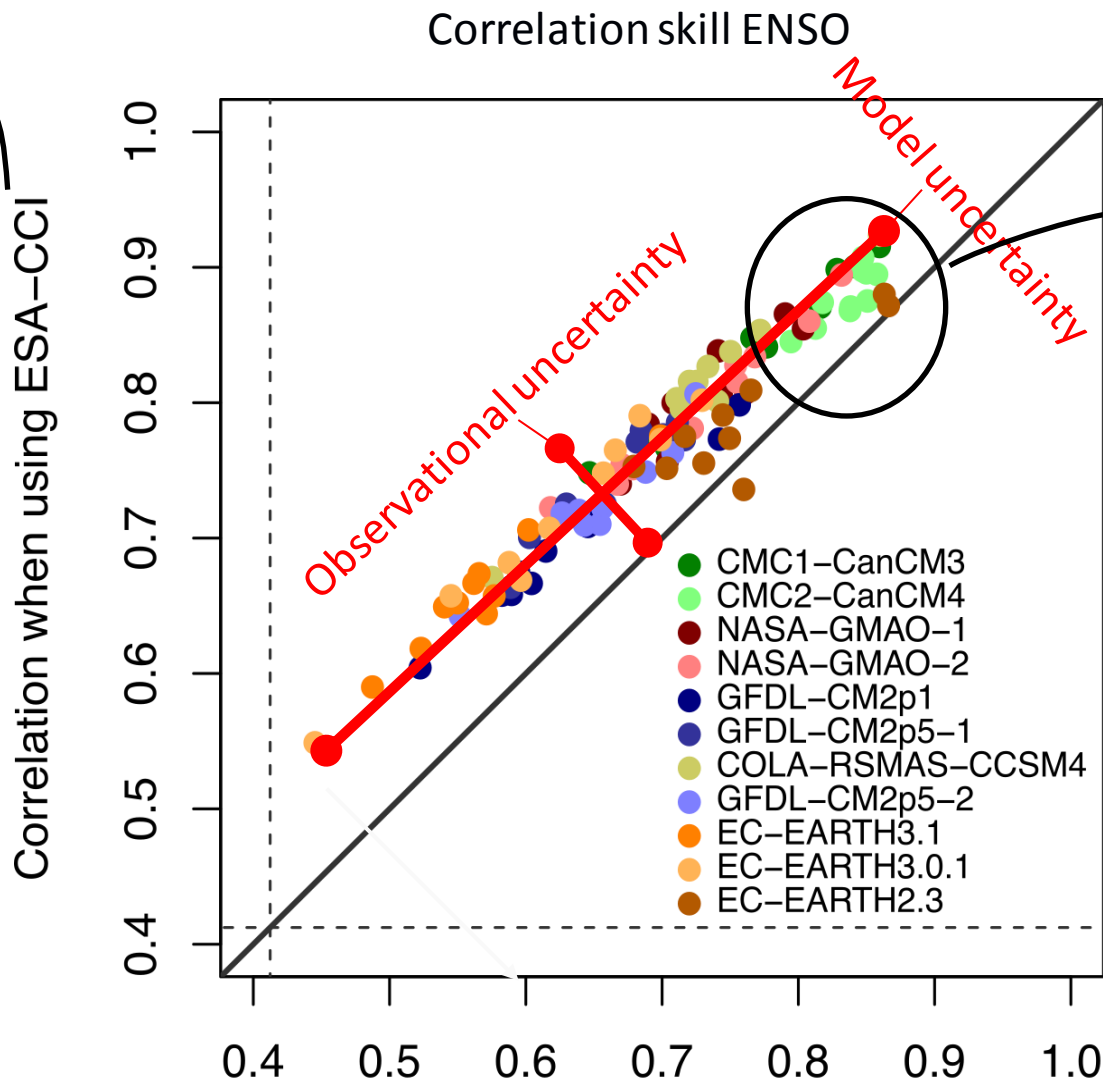
EC-Earth GLOBAL ORCA12-T1279 (ocean and atmosphere at ~10 km!)

IFS: T2M, coupled ORCA12-T1279, 1990-03-10



Models can also be used to estimate the quality of observational estimates.

Independent from the models



How important for individual systems?

BSC is responsible of the development of the evaluation and quality control function of the climate data store of the Copernicus Climate Change Service. This implies ensuring that all the disseminated climate datasets have undergone an adequate quality control process.

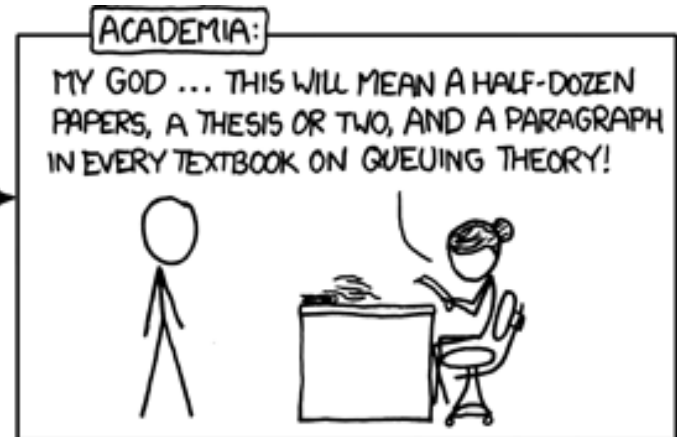


- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators
- Tools to support adaptation and mitigation at global and European level



- Monitors quality of C3S products and services
- Ensures C3S delivers state-of-the-art climate information to end-users
- Identifies gaps in service provision
- Bridges Copernicus with the research agenda in Europe (e.g. H2020, national research projects)

What for?



Is there something in between?



Case studies for specific needs

ASSESSMENT REPORT 3: Dec-Jan-Feb 2014, North-East Brazil

Key event characterisation

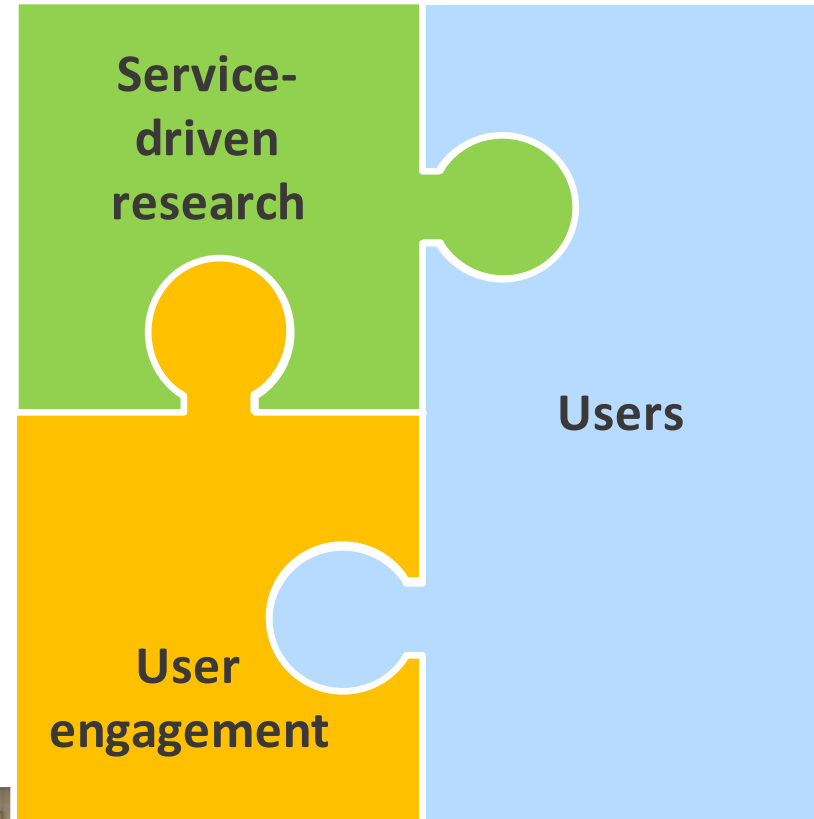
STAKEHOLDER: ALSTOM
AREA: North-East Brazil
COORDINATE: 5.69°-4.94°S 35.93°-35.23°W
SEASON: December, January, February (DJF)
YEAR: 2014/15

RESILIENCE: seasonal wind speed prediction

Mechanisms driving seasonal wind speed variability

Handwritten notes on sticky notes:

- Wind forecast... decided in 2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-94-95-96-97-98-99-100-101-102-103-104-105-106-107-108-109-110-111-112-113-114-115-116-117-118-119-120-121-122-123-124-125-126-127-128-129-130-131-132-133-134-135-136-137-138-139-140-141-142-143-144-145-146-147-148-149-150-151-152-153-154-155-156-157-158-159-160-161-162-163-164-165-166-167-168-169-170-171-172-173-174-175-176-177-178-179-180-181-182-183-184-185-186-187-188-189-190-191-192-193-194-195-196-197-198-199-200-201-202-203-204-205-206-207-208-209-210-211-212-213-214-215-216-217-218-219-220-221-222-223-224-225-226-227-228-229-230-231-232-233-234-235-236-237-238-239-240-241-242-243-244-245-246-247-248-249-250-251-252-253-254-255-256-257-258-259-260-261-262-263-264-265-266-267-268-269-270-271-272-273-274-275-276-277-278-279-280-281-282-283-284-285-286-287-288-289-290-291-292-293-294-295-296-297-298-299-300-301-302-303-304-305-306-307-308-309-310-311-312-313-314-315-316-317-318-319-320-321-322-323-324-325-326-327-328-329-330-331-332-333-334-335-336-337-338-339-340-341-342-343-344-345-346-347-348-349-350-351-352-353-354-355-356-357-358-359-360-361-362-363-364-365-366-367-368-369-370-371-372-373-374-375-376-377-378-379-380-381-382-383-384-385-386-387-388-389-390-391-392-393-394-395-396-397-398-399-400-401-402-403-404-405-406-407-408-409-410-411-412-413-414-415-416-417-418-419-420-421-422-423-424-425-426-427-428-429-430-431-432-433-434-435-436-437-438-439-440-441-442-443-444-445-446-447-448-449-450-451-452-453-454-455-456-457-458-459-460-461-462-463-464-465-466-467-468-469-470-471-472-473-474-475-476-477-478-479-480-481-482-483-484-485-486-487-488-489-490-491-492-493-494-495-496-497-498-499-500-501-502-503-504-505-506-507-508-509-510-511-512-513-514-515-516-517-518-519-520-521-522-523-524-525-526-527-528-529-530-531-532-533-534-535-536-537-538-539-540-541-542-543-544-545-546-547-548-549-550-551-552-553-554-555-556-557-558-559-560-561-562-563-564-565-566-567-568-569-570-571-572-573-574-575-576-577-578-579-580-581-582-583-584-585-586-587-588-589-590-591-592-593-594-595-596-597-598-599-600-601-602-603-604-605-606-607-608-609-610-611-612-613-614-615-616-617-618-619-620-621-622-623-624-625-626-627-628-629-630-631-632-633-634-635-636-637-638-639-640-641-642-643-644-645-646-647-648-649-650-651-652-653-654-655-656-657-658-659-660-661-662-663-664-665-666-667-668-669-670-671-672-673-674-675-676-677-678-679-680-681-682-683-684-685-686-687-688-689-690-691-692-693-694-695-696-697-698-699-700-701-702-703-704-705-706-707-708-709-710-711-712-713-714-715-716-717-718-719-720-721-722-723-724-725-726-727-728-729-730-731-732-733-734-735-736-737-738-739-740-741-742-743-744-745-746-747-748-749-750-751-752-753-754-755-756-757-758-759-760-761-762-763-764-765-766-767-768-769-770-771-772-773-774-775-776-777-778-779-780-781-782-783-784-785-786-787-788-789-790-791-792-793-794-795-796-797-798-799-800-801-802-803-804-805-806-807-808-809-810-811-812-813-814-815-816-817-818-819-820-821-822-823-824-825-826-827-828-829-830-831-832-833-834-835-836-837-838-839-840-841-842-843-844-845-846-847-848-849-850-851-852-853-854-855-856-857-858-859-860-861-862-863-864-865-866-867-868-869-870-871-872-873-874-875-876-877-878-879-880-881-882-883-884-885-886-887-888-889-890-891-892-893-894-895-896-897-898-899-900-901-902-903-904-905-906-907-908-909-910-911-912-913-914-915-916-917-918-919-920-921-922-923-924-925-926-927-928-929-930-931-932-933-934-935-936-937-938-939-940-941-942-943-944-945-946-947-948-949-950-951-952-953-954-955-956-957-958-959-960-961-962-963-964-965-966-967-968-969-970-971-972-973-974-975-976-977-978-979-980-981-982-983-984-985-986-987-988-989-990-991-992-993-994-995-996-997-998-999-1000

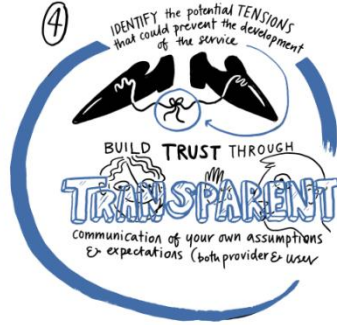


Participatory approaches

SUCCESSFUL CLIMATE SERVICE

Principles

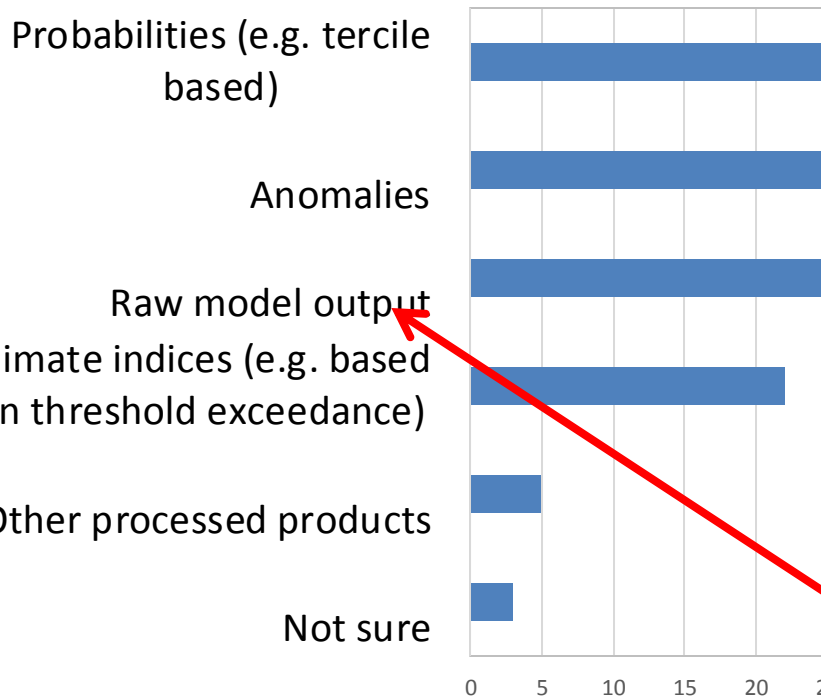
Climate data is not climate information



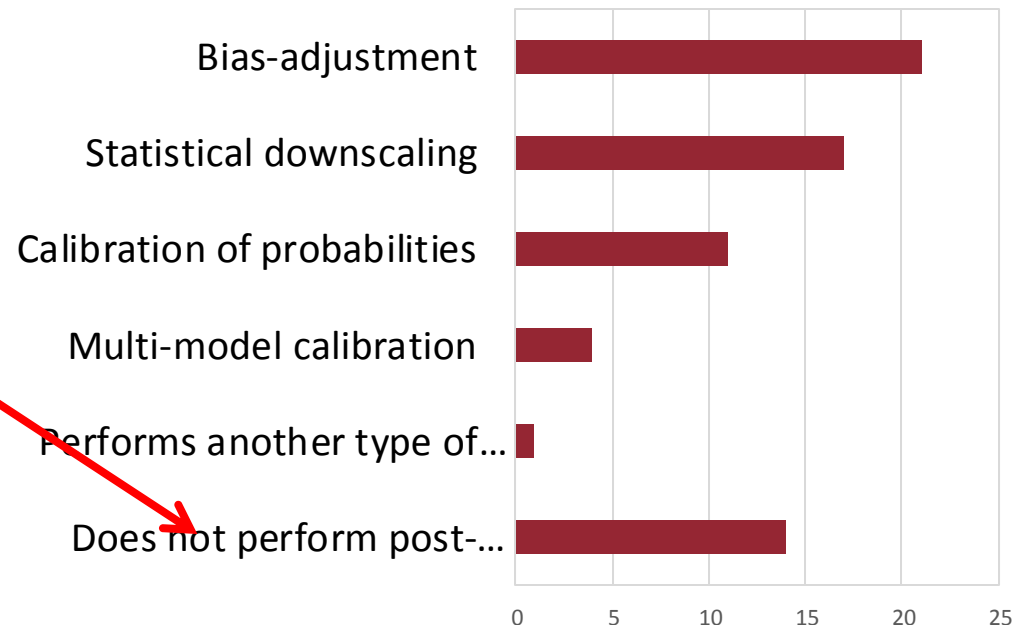
EUPORIAS

Results from a user survey performed in the framework of the Copernicus Climate Change Service contract QA4Seas.

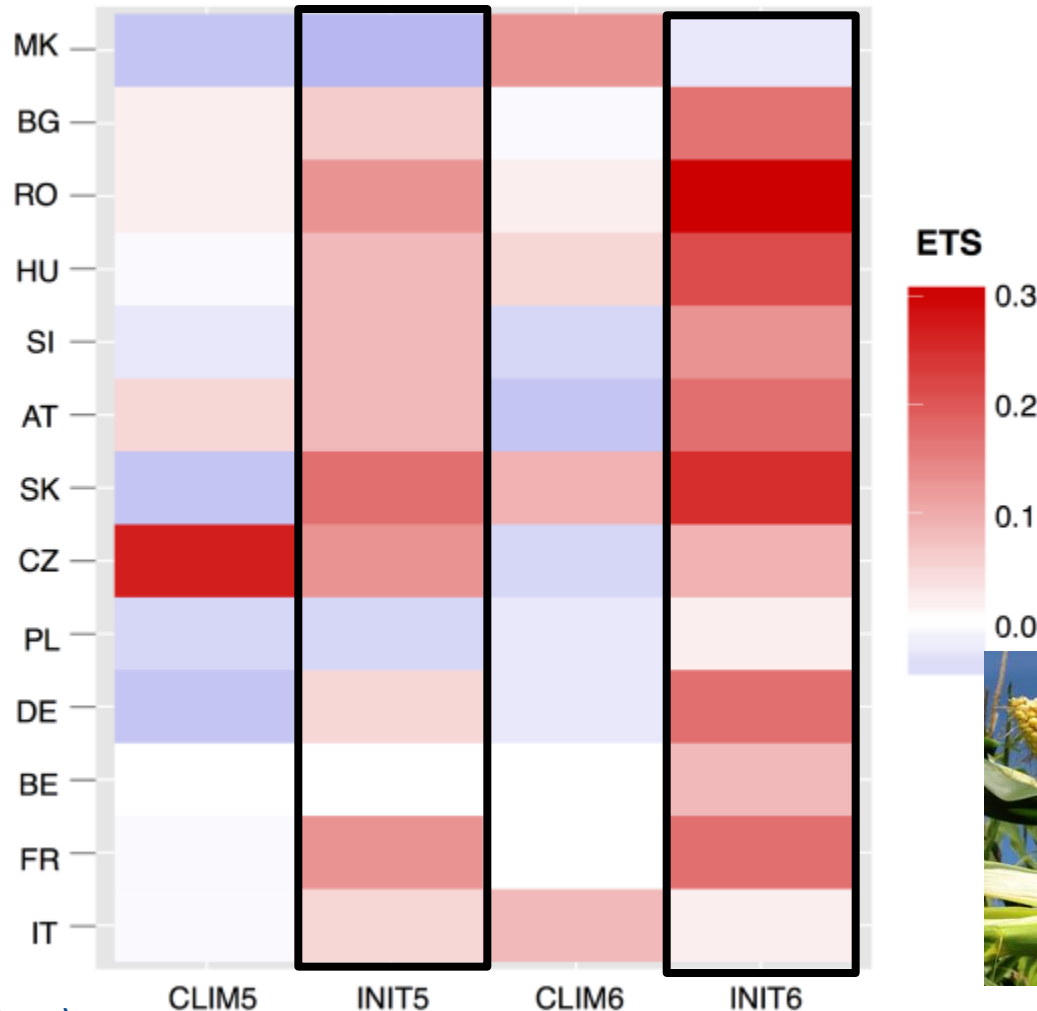
"What kind of data from global seasonal forecasts do you use?"



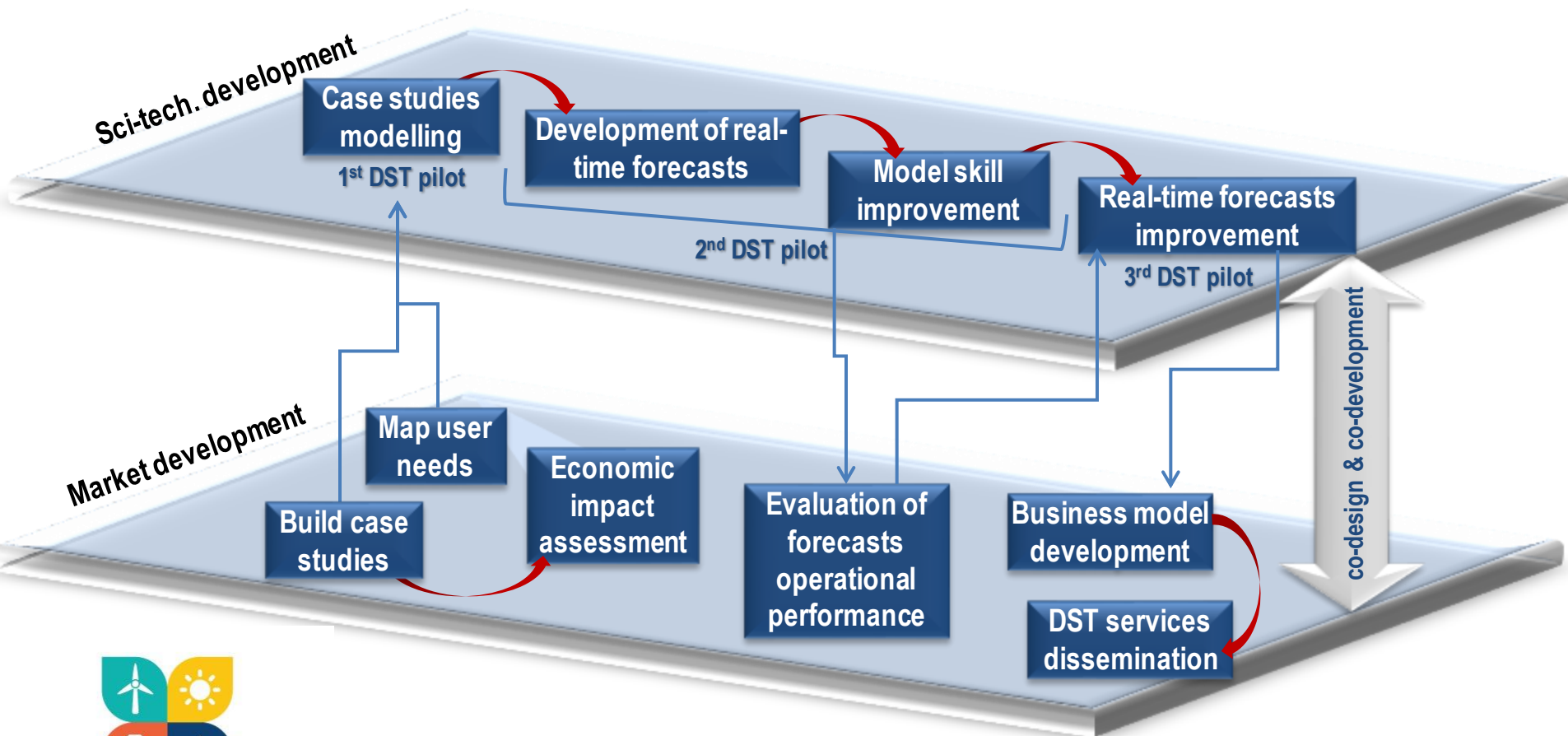
"What type of adjustment post-processing do you perform on the data before using it?"



Equitable threat score (ETS) of predictions of poor maize yield (lower quartile) from EC-Earth when the land-surface uses realistic initial conditions (INIT) wrt conditions with no interannual information (CLIM).



Prototypical climate service for energy



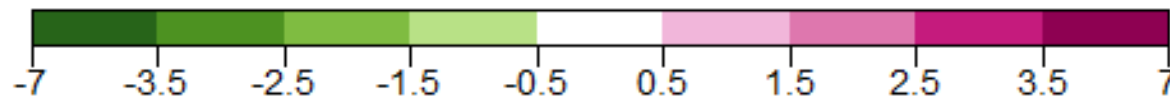
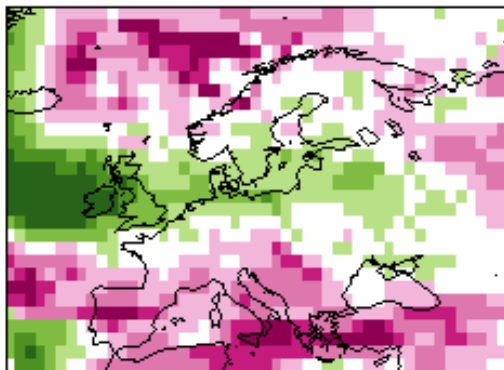
S2S4E

Climate Services
for Clean Energy



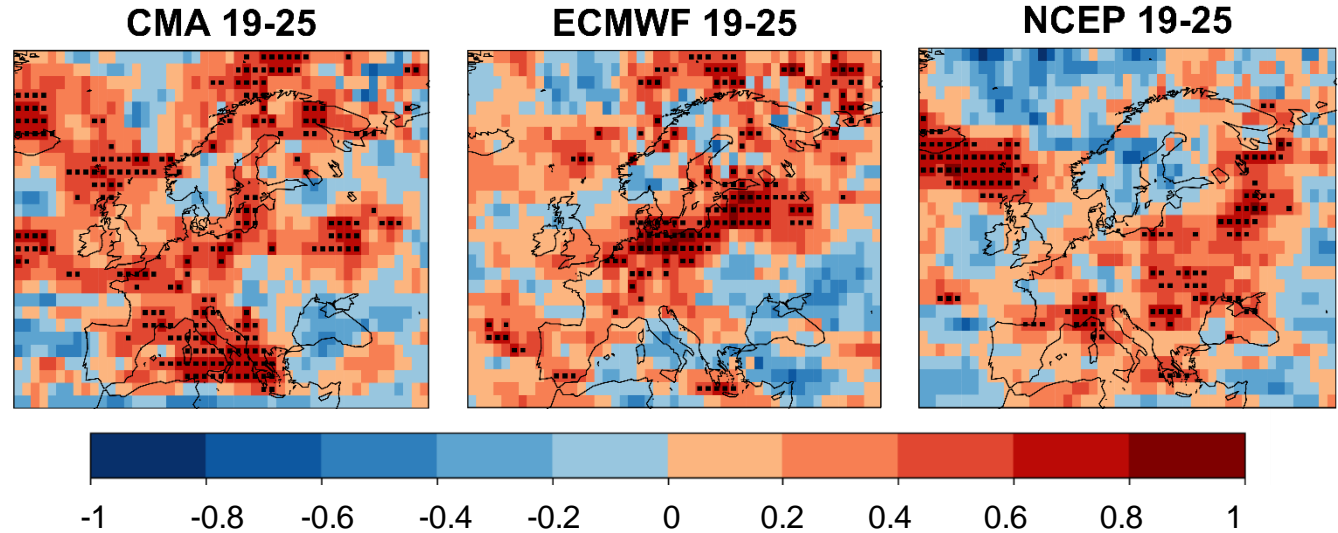
10-metre wind speed for 2-8 February 2015 (m/s)

ERA-Interim



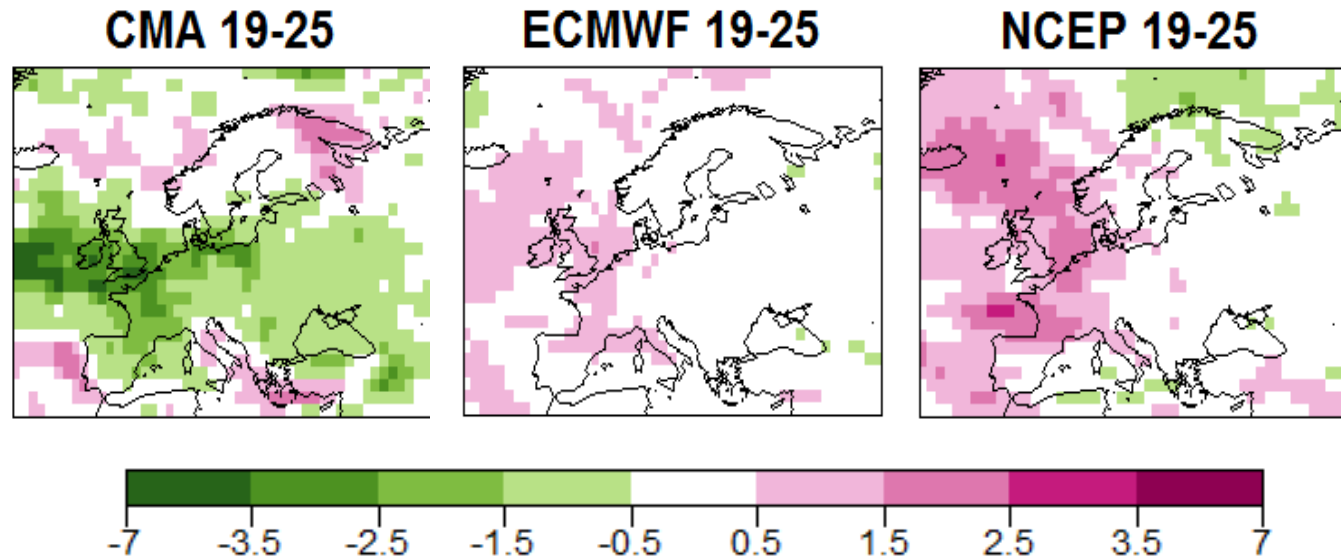
Predictions for wind energy

Ensemble-mean correlation (institution and forecast time)

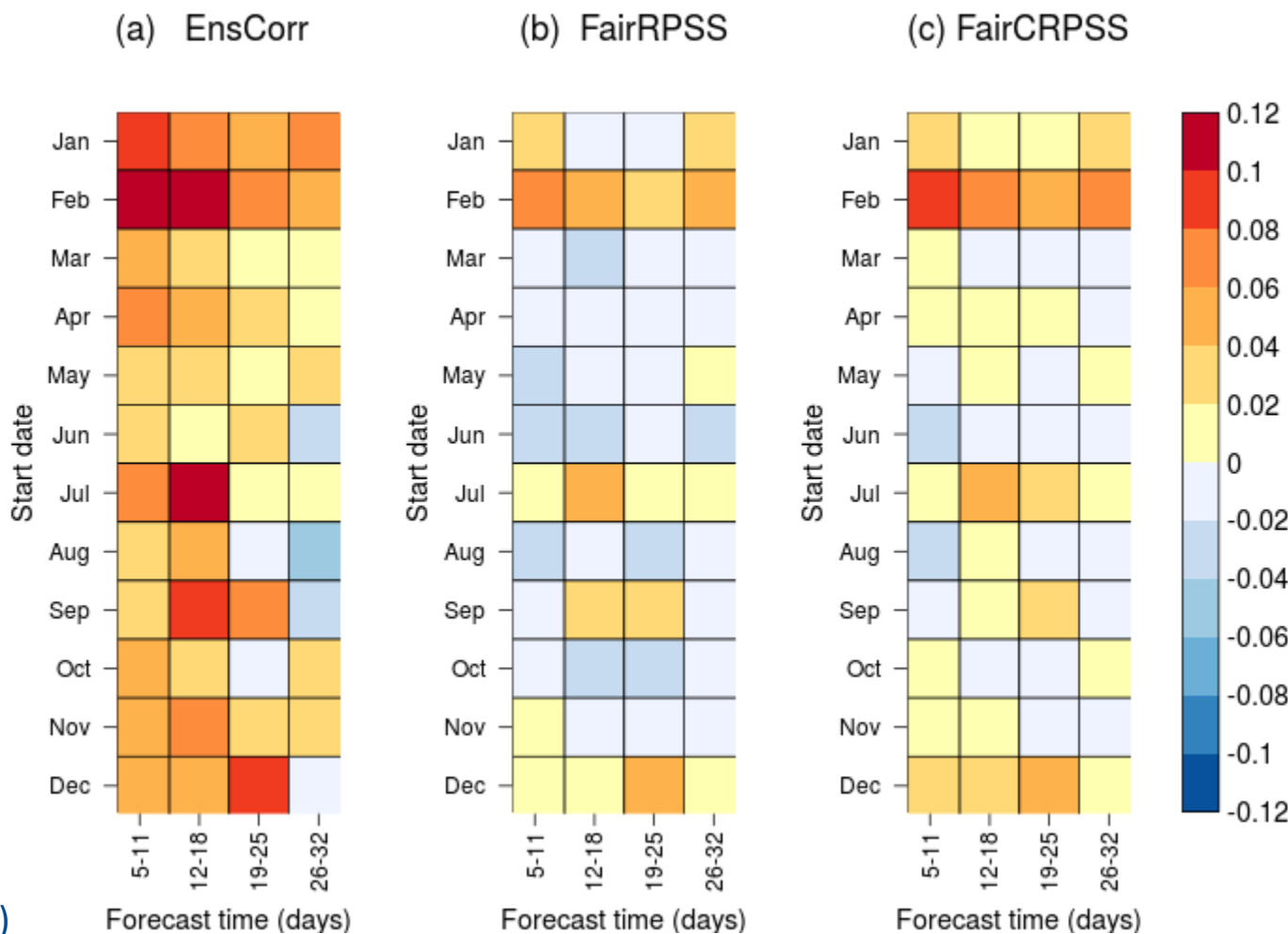


Ensemble-mean forecast

ERA-Interim

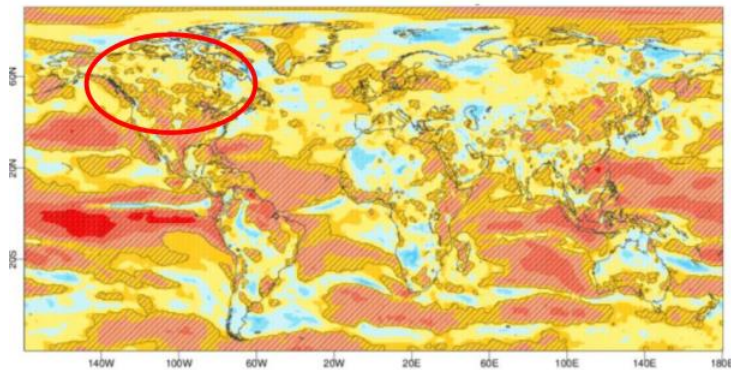


Forecast quality improvement in 10-metre wind speed of the ECMWF sub-seasonal forecast system between the CY43R3 and CY40R1 versions for the North Sea region over 1996-2013.

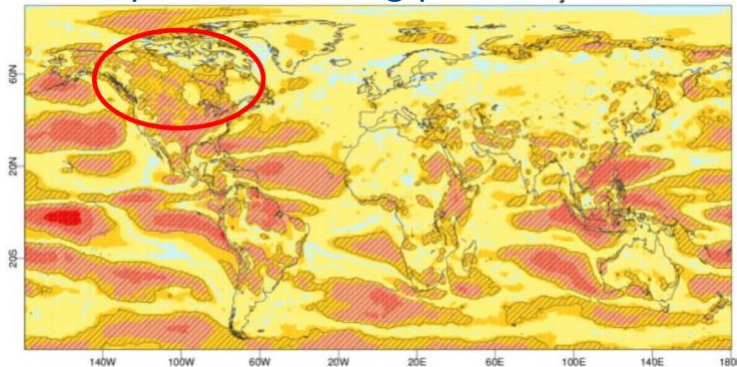


ECMWF S4 10-metre wind speed forecasts for DJF corrected with the predicted Niño3.4 index on a regression estimated using ERA-Interim.

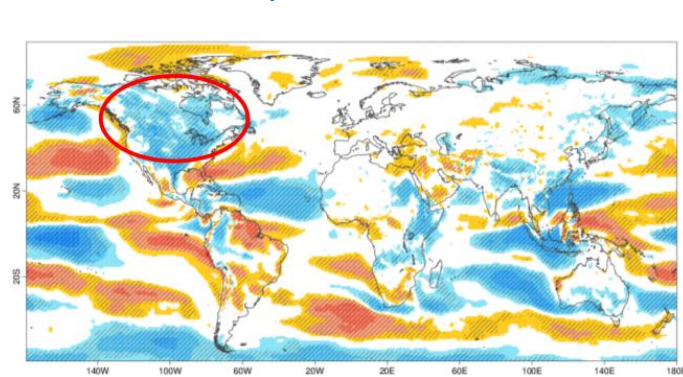
Correlation of the ECMWF S4 ensemble-mean prediction (1981-2015)



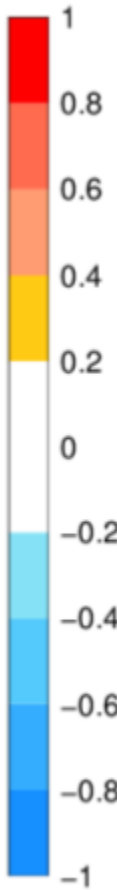
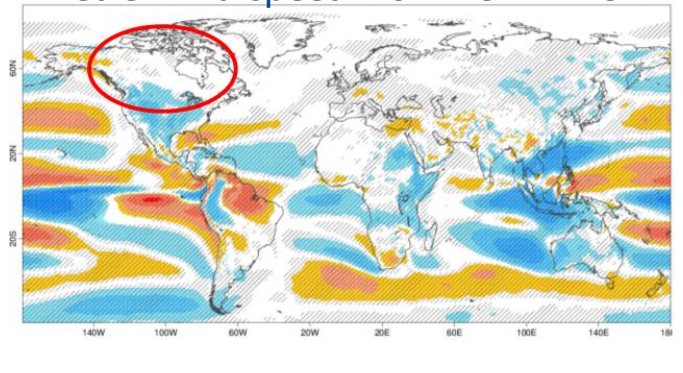
Correlation of the ECMWF S4 ensemble-mean prediction using predicted Niño3.4



Point correlation of Niño3.4 and 10-metre wind speed from ERA Interim

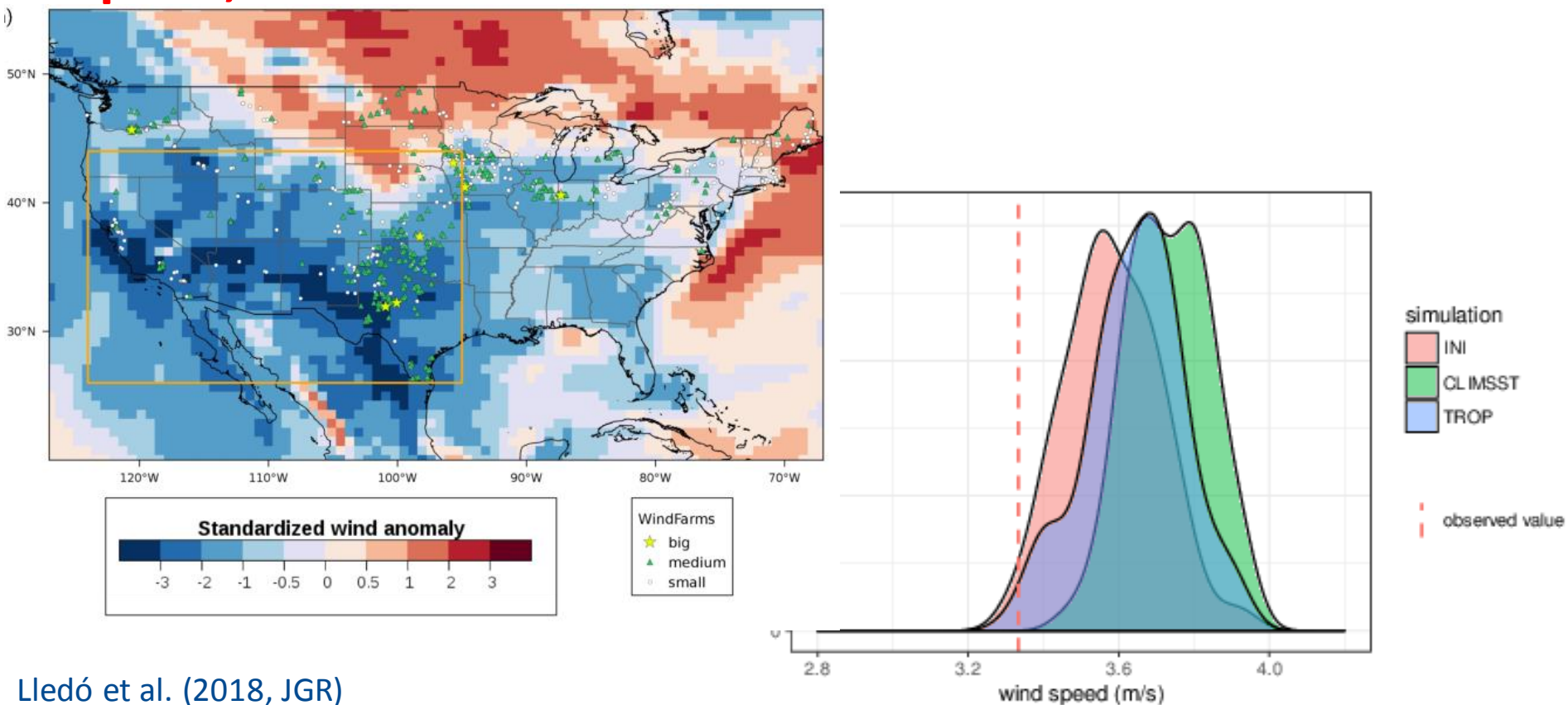


Point correlation of Niño3.4 and 10-metre wind speed from ECMWF S4

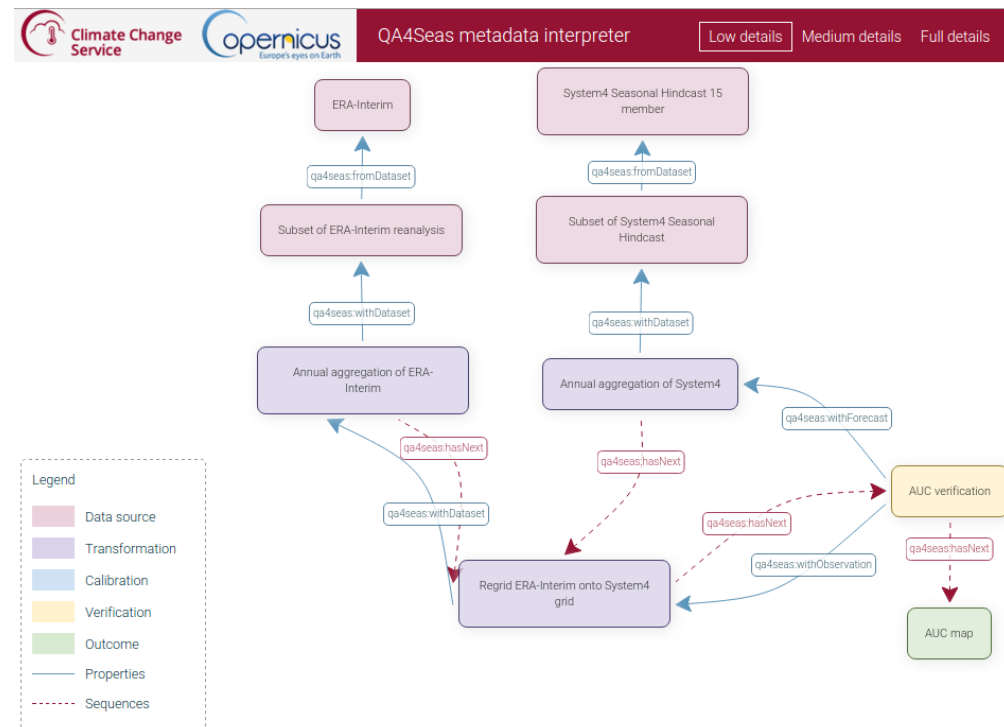
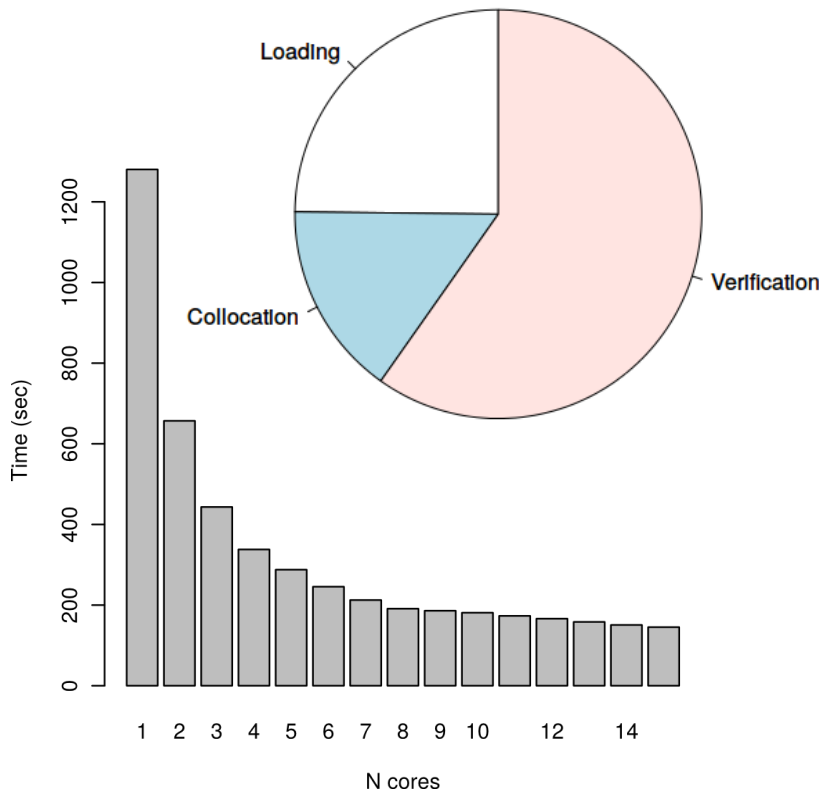


Attribution of the JFM 2015 wind drought over North America. Both west tropical and extratropical Pacific SSTs play a role in the wind drought.

Shouldn't have been for the wind energy managers' request, we'd never have looked into this issue.



- **Computing performance is key:** (left) scalability of a ROC area estimate using loader, SpecsVerification and easyVerification.
- An RDF-based approach aiming at the reproducibility of objects (NetCDF file, image) with human and machine-readable solution using a semantic metadata model has been created in QA4Seas.

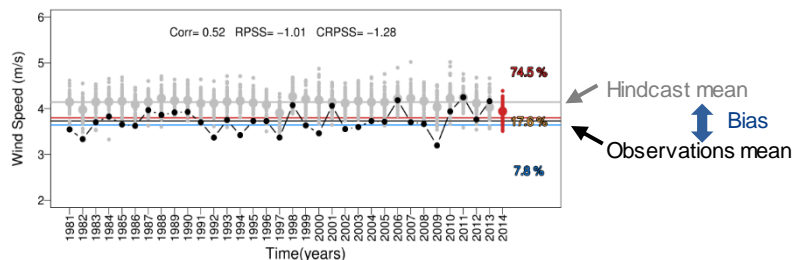


A new paradigm has come to stay: user-driven research

- **Progress:** opportunities for research and services to grow together, involve private sector in research to value our research.
- **Heterogeneity:** link to and merge our data with communities with larger impact (urban, arts, social).
- **Education:** in the era of open data, take advantage of the open education opportunities.
- **Standards:** in a collaborative environment standards are a must and everyone's (researchers, users and providers) responsibility.
- **Efficiency:** researchers are asked to do more for less, which leads us to increased collaboration, organisation, sharing, etc.
- **Technology:** make the most of a rapidly evolving technology (heterogeneous hardware, software, mobile data capture, visualisation, computing and storage outsourcing).

Bias adjustment

Raw data



Method	Equation	Description	Result
Simple bias correction	$y_{j,i} = (x_{ij} - \bar{x}) \frac{\sigma_{ref}}{\sigma_e} - \bar{o}$	Based on the assumption that both the reference and forecasted distribution are well approximated by a Gaussian distribution.	
Calibration method	$y_{j,i} = \alpha x_i + \beta z_{ij}$	Variance inflation modifies the predictions to have the same interannual variance as the reference dataset and corrects the ensemble spread to improve the reliability.	
Quantile mapping	$y_{j,i} = (ecdf^{ref})^{-1} ecdf^{mod}(x_{ij})$	It determines for each forecast to which quantile of the forecast climatology it corresponds, and then they are mapped to the corresponding quantile of the observational climatology.	

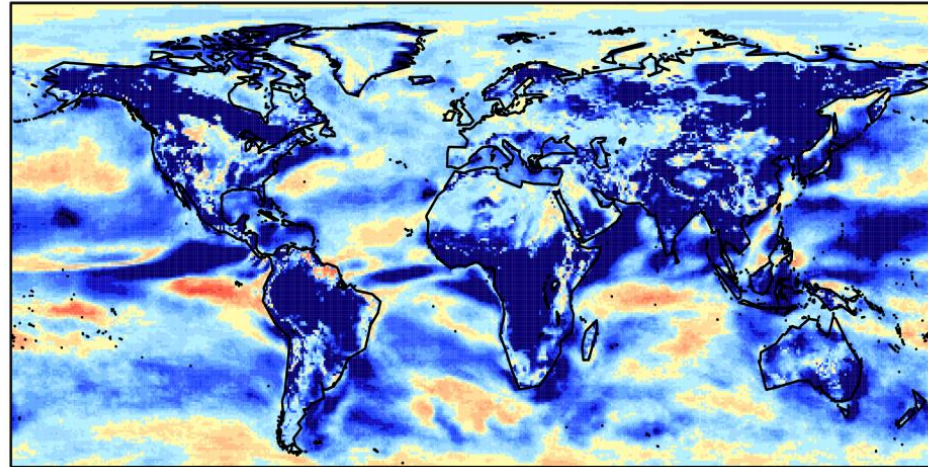
Impact of bias adjustment

Ranked Probability Skill Score

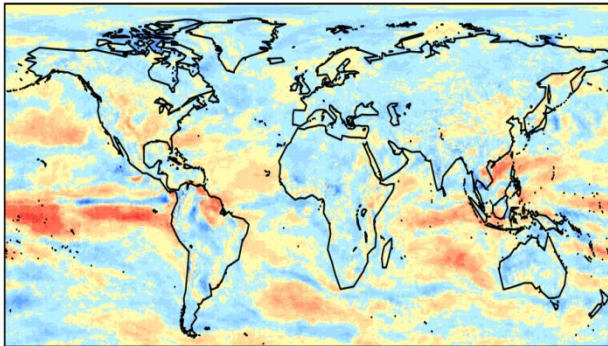
$$RPS = \frac{1}{M-1} \sum_{m=1}^M \left[\left(\sum_{k=1}^m p_k \right) - \left(\sum_{k=1}^m o_k \right) \right]^2$$

$$RPSS = \frac{\overline{RPS} - \overline{RPS}_{reference}}{0 - \overline{RPS}_{reference}} = 1 - \frac{\overline{RPS}}{\overline{RPS}_{reference}}$$

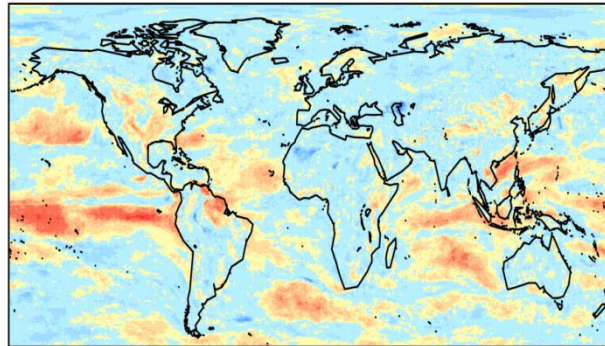
Uncorrected



Simple



Calibration



Q-Q mapping

