



Center for Climate
and Resilience Research
www.CR2.cl



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FINANCIADA



CR2MET: Metodología y Aplicación

Juan P. Boisier y CR2MET team (Tomás Gomez)
Center for Climate and Resilience Research (CR)²

- www.cr2.cl
- [@cr2_uchile](https://twitter.com/cr2_uchile)
- [/cr2uchile](https://facebook.com/cr2uchile)

Necesidad de datos meteorológicos distribuidos a escala regional (< 30 km)

- Periodo largo (climatológico)
- Estimación robusta de valores medios
- Variabilidad coherente (al menos a escala mensual)

¿Para qué?

- Estudio de clima e hidrología regional (cuencas medias-grandes)
- Forzante atmosférica en modelos de superficie (hidro, vegetación)
- Evaluación modelos de circulación regional
- Referencia para regionalización de modelos global de clima
- Análisis de co-varianza (e.g., NDVI-Temp)
- ?

Métodos de ajuste o regionalización

Based on satellite products	Interpolation methods	Statistical downscaling	Dynamical downscaling	Regional reanalysis
<ul style="list-style-type: none"> Highly valuable information in regions with no direct obs. ~ Simple adaptation Indirect measurements (biases) Period limitation & gaps 	<ul style="list-style-type: none"> Low biases & high correlations near stations Fast & cheap (time & CPU) Very large uncertainties in extrapolated (data-sparse) regions (Andes, Patagonia) 	<ul style="list-style-type: none"> ~ Low biases wrt to obs ~ Fast & cheap Uncertainties in data-sparse regions Stat. model (calibration) biases Dependance on the LS forcing (Reanalysis) 	<ul style="list-style-type: none"> Process-based (valuable info in data-sparse areas) Multiple variables Expensive Model biases Dependance on the LS forcing (Reanalysis) 	<ul style="list-style-type: none"> Large space-time coherence with obs. Process-based Multiple variables Very expensive Useful if a rich synoptic dataset is there to be assimilated

Modelos lineales de regionalización estadística de P.

Ajuste simple

$$P_{LO} = \alpha + \beta P_{LS}$$

variables de gran
escala (reanálisis)

Semi-empírico

$$P_{LO} = \alpha + \beta P_{LS} + \gamma \vec{Q}_{LS} \cdot \nabla Z$$

Topografía

Empírico con
muchos predictores

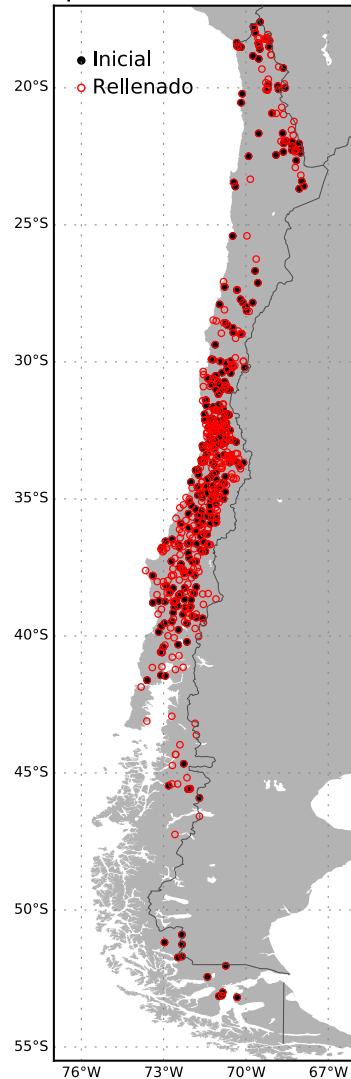
$$P_{LO} = \sum \alpha^{(i)} V_{LS}^{(i)} + \sum \sum \beta^{(i,j)} V_{LS}^{(i)} V_Z^{(j)}$$

Precipitación

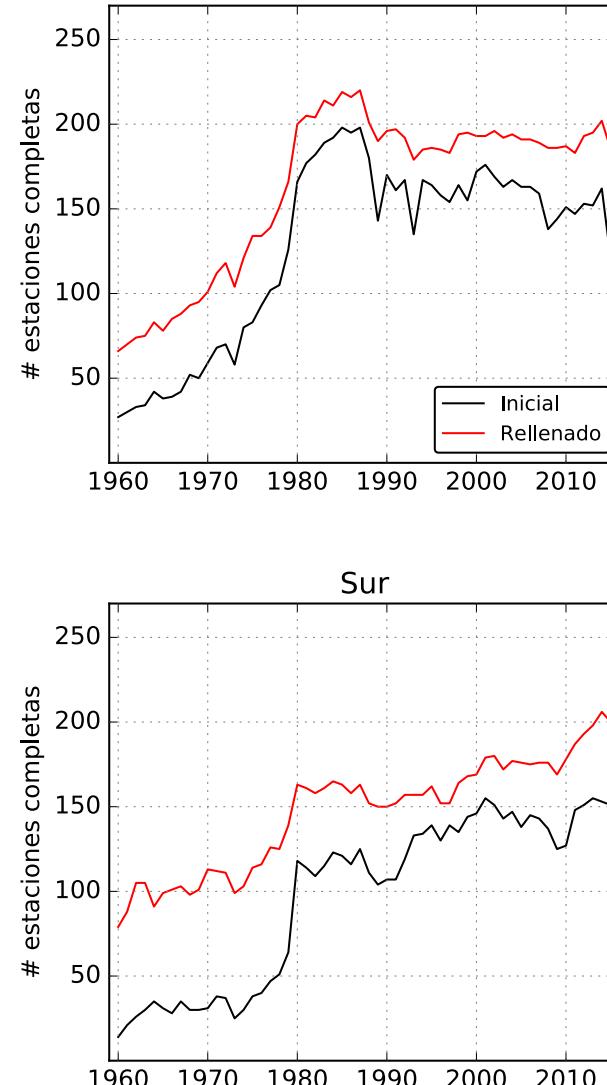
Fuente de datos

- P diaria CR2
- Q control
- Relleno

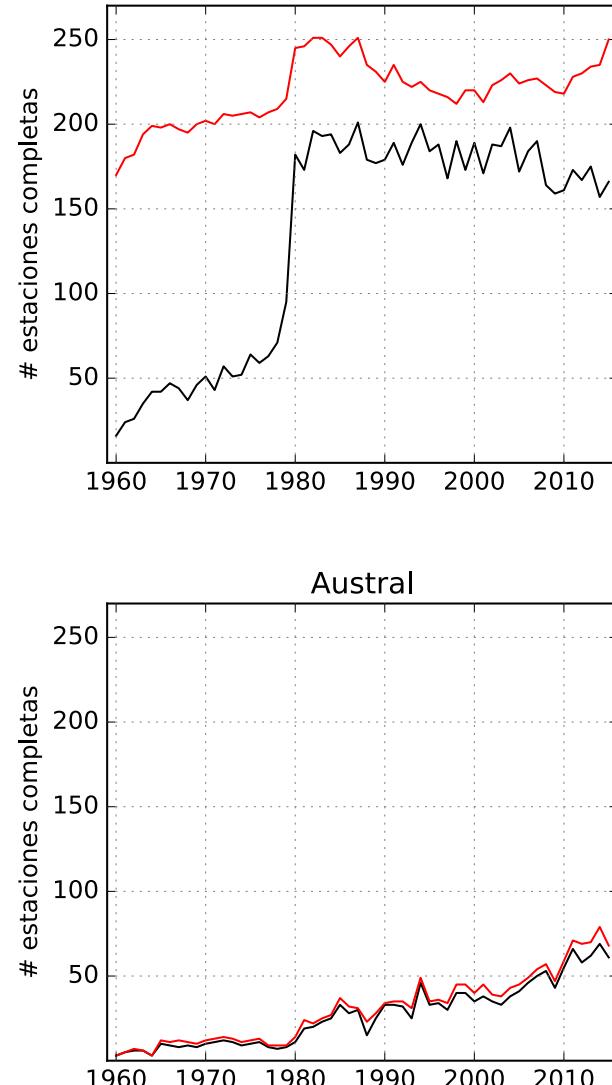
Estaciones 90%+ compl.
periodo 1985-2015



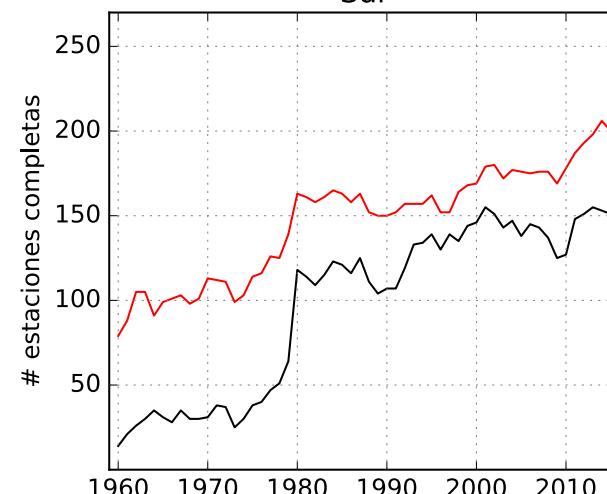
Norte



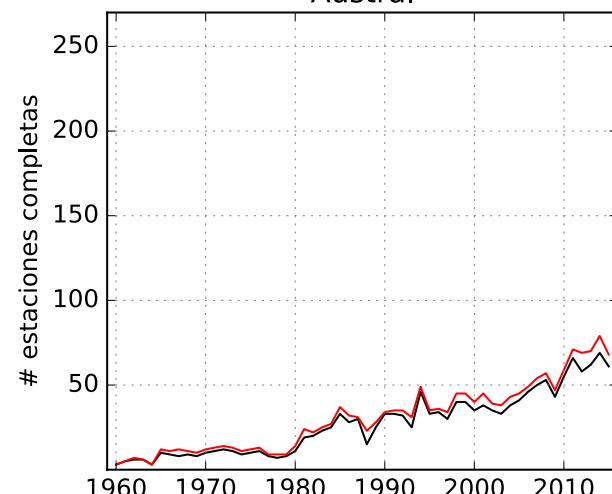
Centro



Sur

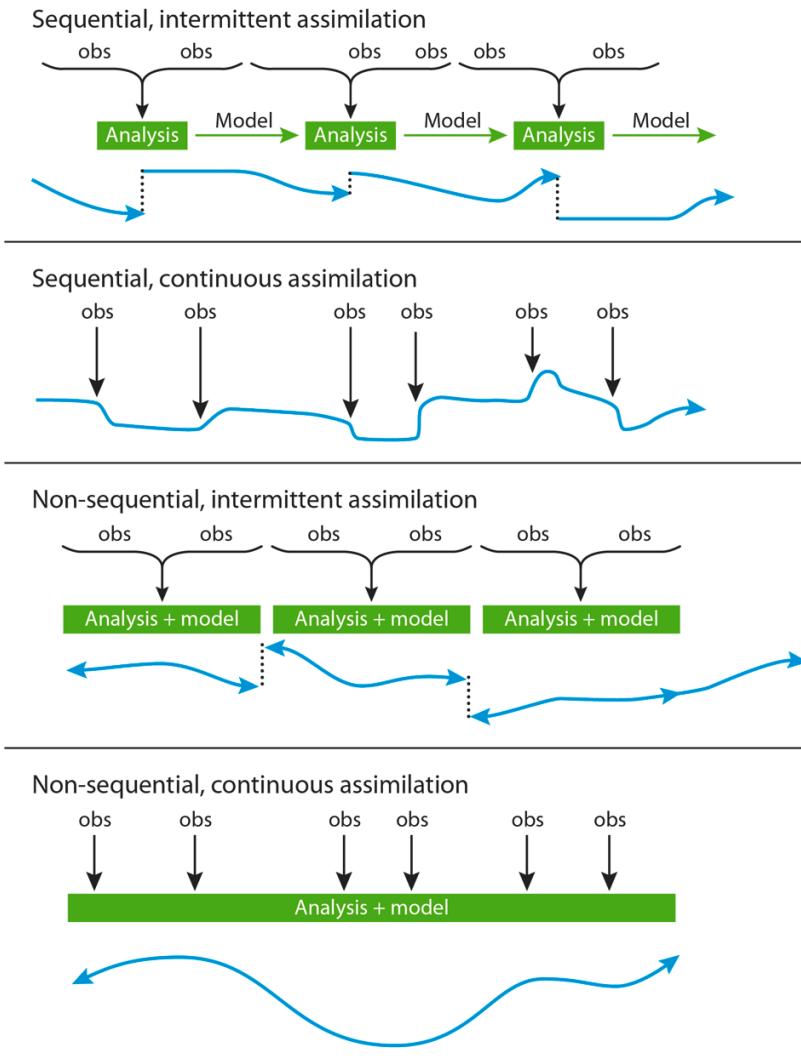
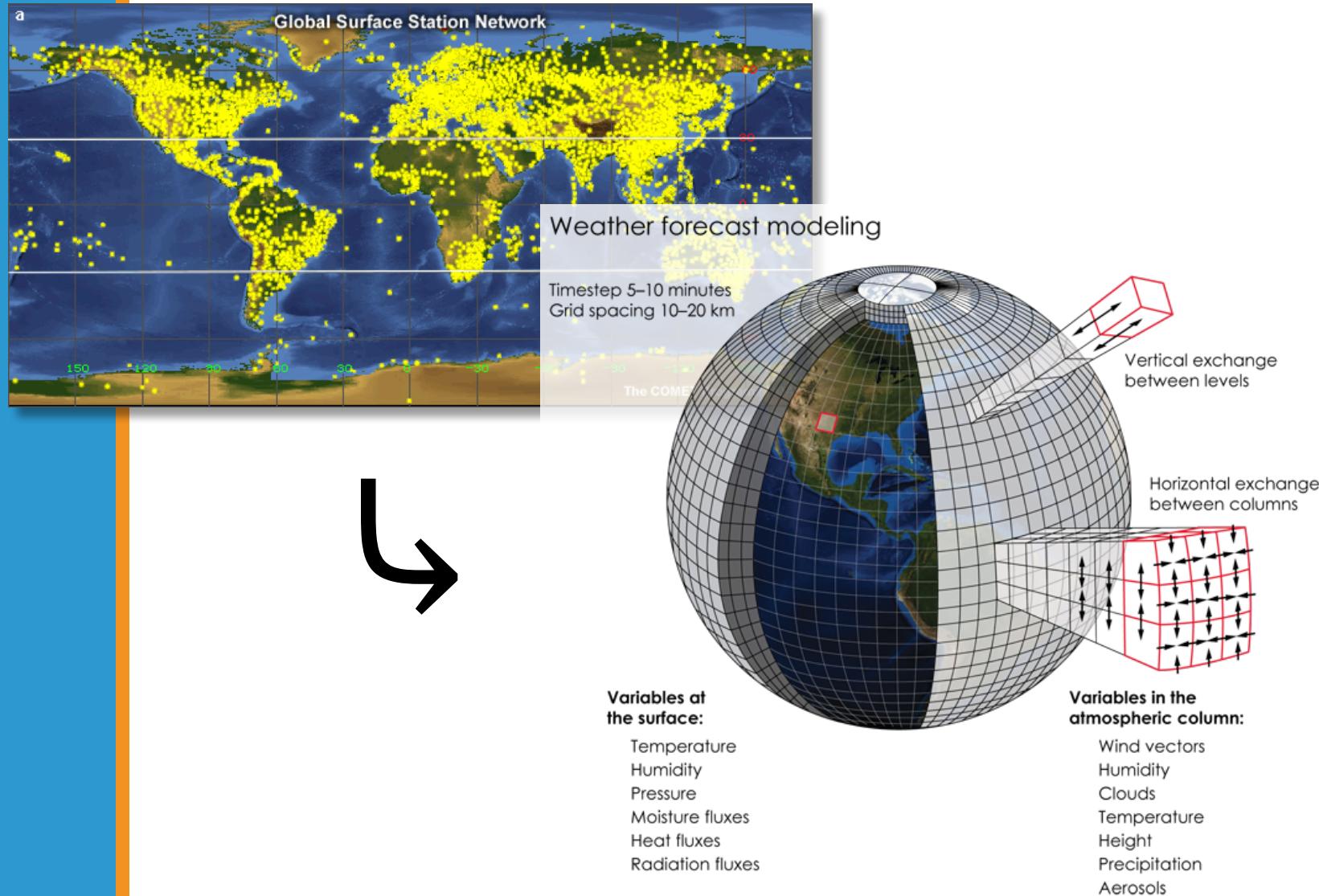


Austral



Precipitación

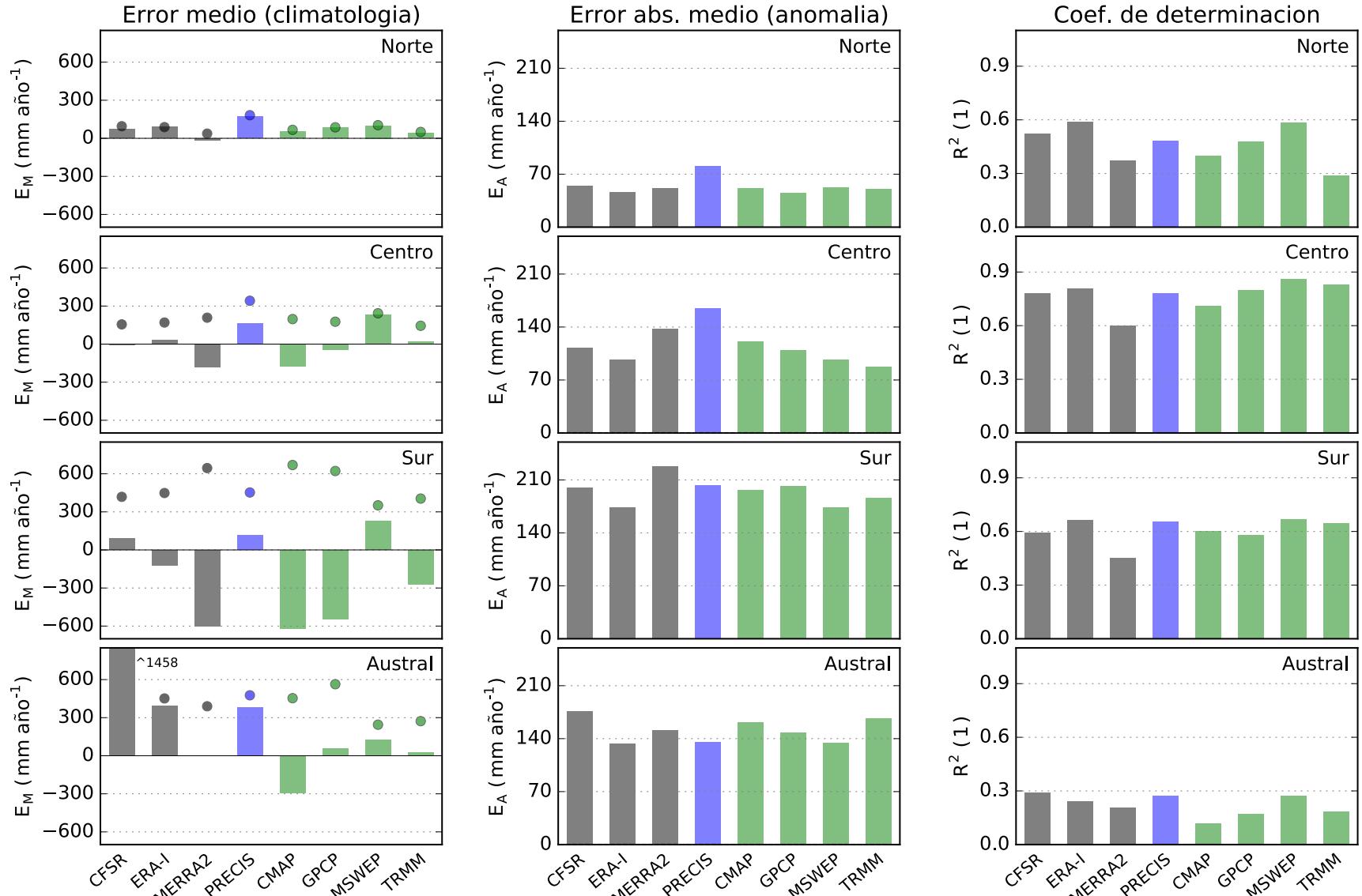
Fuente de datos: Re-análisis



Precipitación

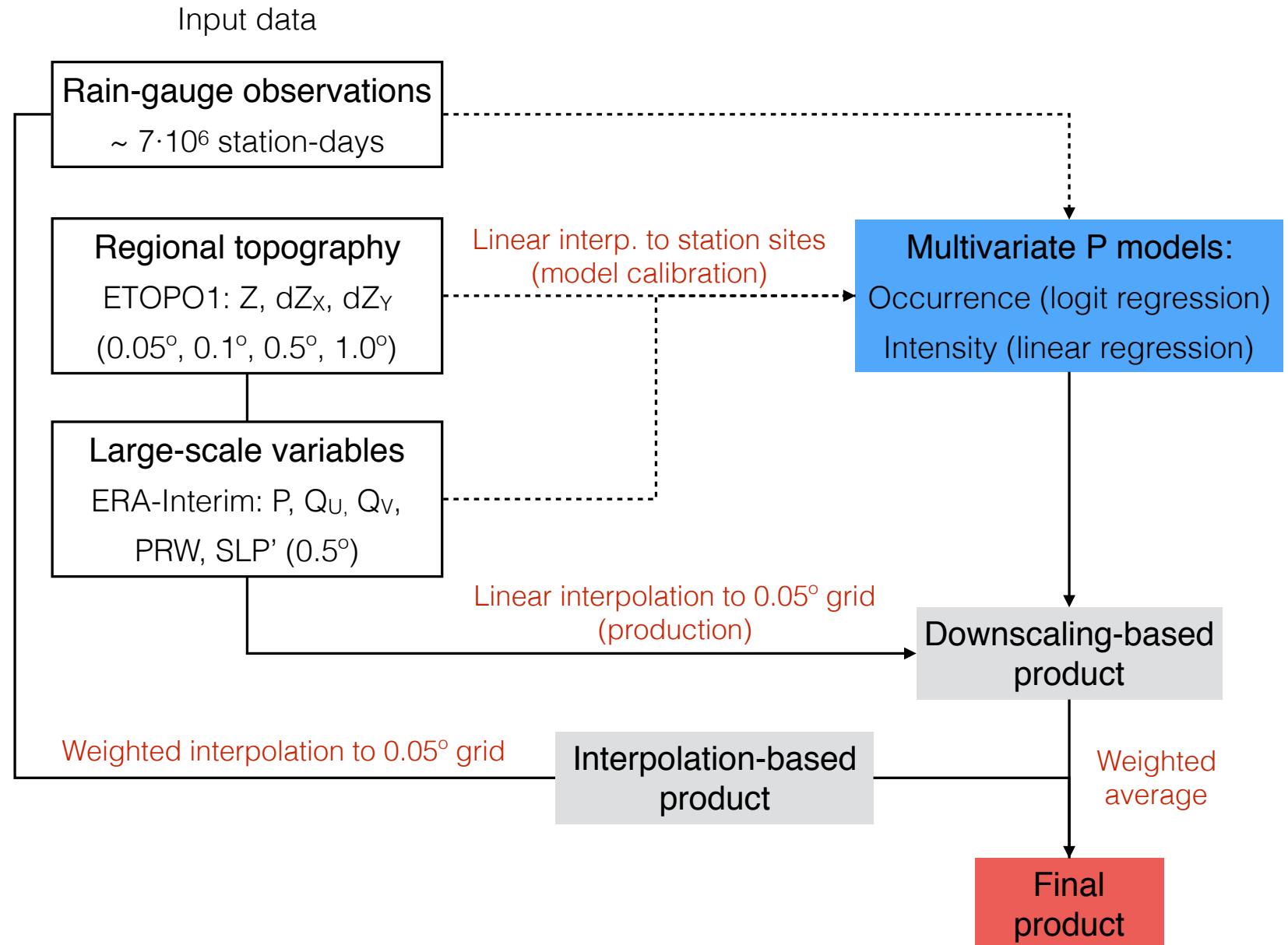
Fuente de datos

Evaluación reanálisis
y otros productos de
baja resolución



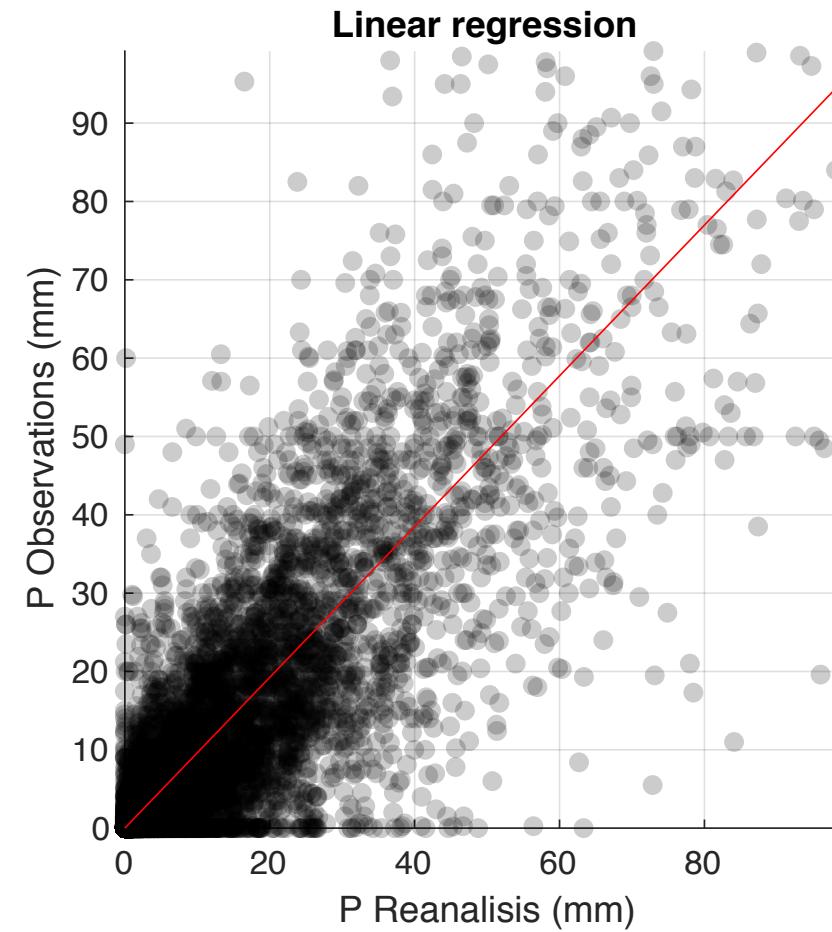
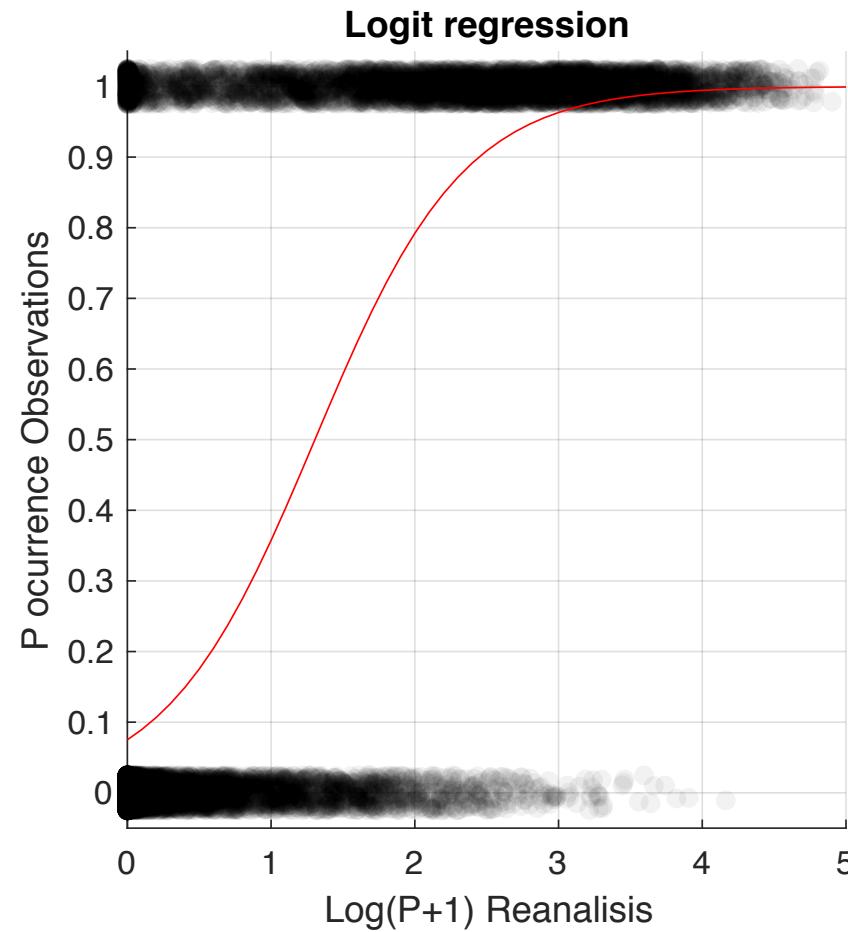
Precipitación

Esquema v1.3.x



Precipitación

Esquema v1.3.x



Esquema v1.3.x

- La calibración considera la estación del año de forma independiente (mes 0, -1, +1)
- También se separa por bandas de latitud
- Se utiliza una muestra menor al total de observaciones disponibles
 - Permite generar ensambles y cuantificar incertidumbre
 - Se busca tb que muestreo temporal (grande) y espacial (-) compitan
- Varios parámetros de calibración

Precipitación

```
%% PARAMETER SETTING

% files paths
home_dir      = '/Users/jboisier/';
path          = [home_dir 'CR2MET_v2/pr/'];

test_mode     = 1;           % Set to 1 to evaluate model, otherwise to write model params
disp_fig      = 1;           % Set to 1 to display figures (recommended in test mode)
verbose       = 1;           % set to 1 to high verbosity (recommended in test mode)
% note: test mode serves to check the spatial (domain) and time consistency
% between forcing data and observations
% it also evaluate the model performance

% calibration period & month(s)
yri           = 2000;         % first year
yrf           = 2016;         % last year
mon_list      = 7;           % single or list of months to compute (e.g., 1:12)

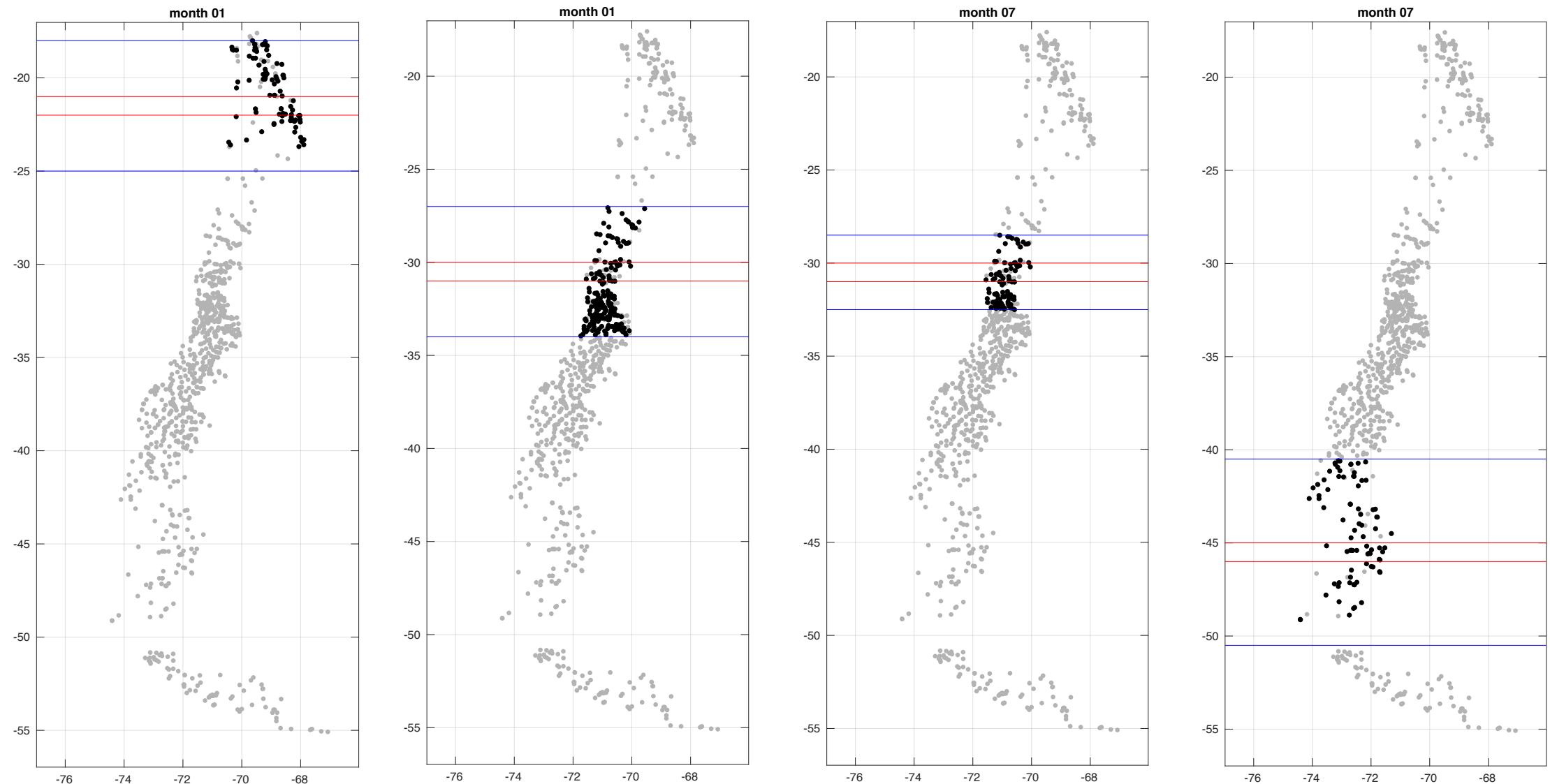
% calibration sample
nd_stn_min    = 300;          % minimum # of valid obs. per station (incl. neiboring months)
nd_stn_rain_min = 10;          % minimum # of rainy days per station (incl. neiboring months)

ns_reg_min    = 80;           % minimum # of stations to consider in a given region
ns_reg_rain_min = 40;          % minimum # of stations with rain to consider in a given region

nd_stn_sample = 100;          % random sample size per station & run (should be <= nd_stn_min)
rain_frac_min = .2;           % minimum fraction o rainy days within calibration sample
% note than total sample size is >= than ns_reg_min*nd_stn_sample

% ensemble size
n_ens         = 1;           % set to 1 in test mode
```

Ejemplo regiones de calibración



Precipitación

```
% regression model parameters
model_order = 1.5;
% regression model order. 1: linear, 1.5: incl. cross terms; 2: all 2nd order terms
% topo_res    = {'005'};
topo_res    = {'005', '025', '05'};
% resolutions used for topographic predictors (degree, 005 > 0.05 deg)
% note that finer resolution should match the final grid

% list reanalysis variables to be used as predictors
% pr should go first !!!
%ls_vars      = {'pr', 'logpr', 'lsp', 'cp', 'qu', 'qv', 'prw'};
ls_vars      = {'pr', 'logpr'};
%ls_vars      = {'pr', 'logpr', 'iqu', 'iqv', 'tcw'};

% Logistic regression for pr occurrence
use_logit    = 0;           % Set to 1 to compute logit, otherwise set uses MLR

% observations file
obs_file     = 'pomin_80_r2min_75_swfit_1_maxel_10';

% Regions to compute
%REGlats      = (-17:-1:-55)';   % All domain
REGlats      = -45;           % single lat in test mode

dlat_min     = 1.5;           % defines effective minimum lat range for stn sample selection

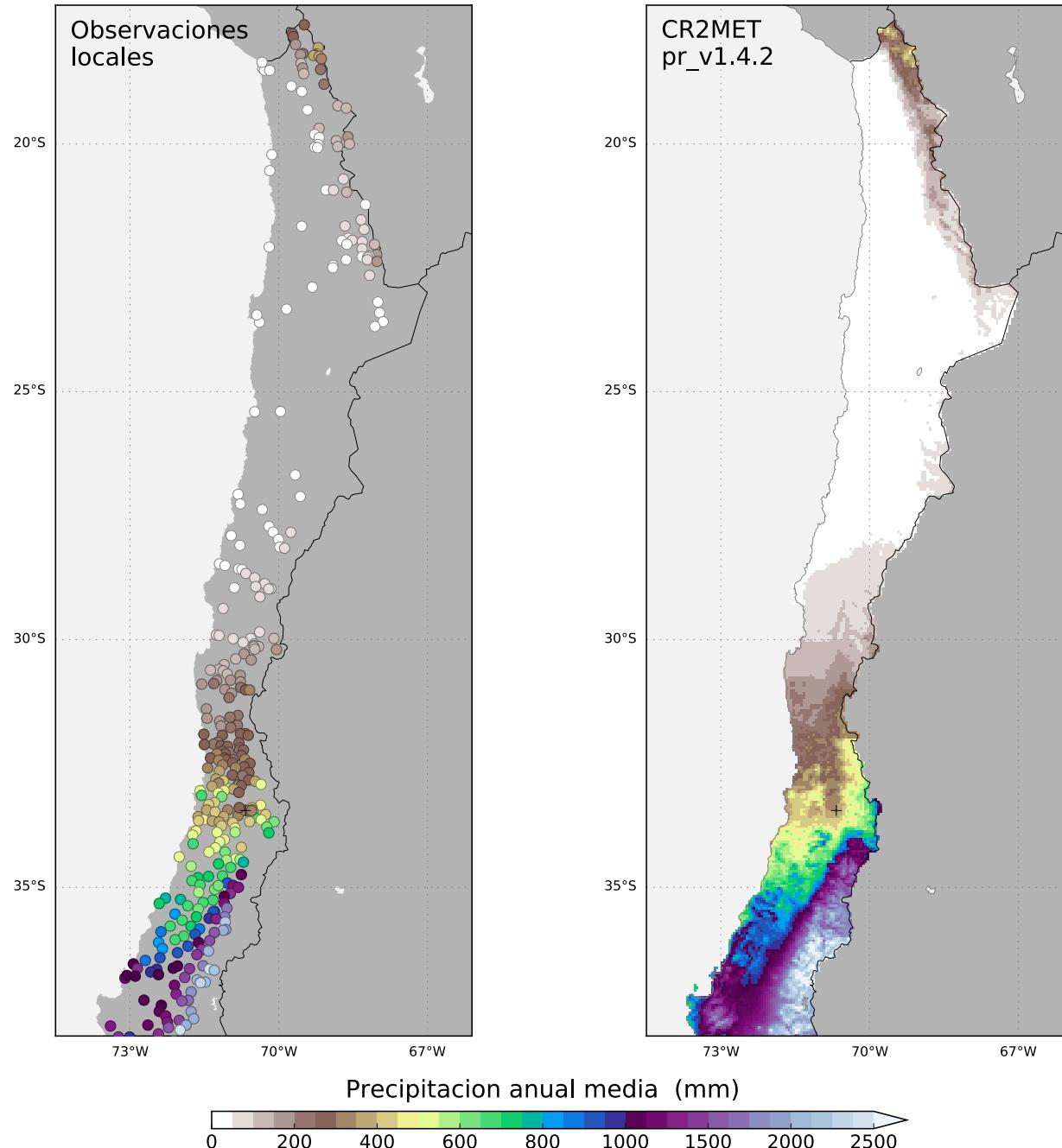
pday_min     = 0.1;           % acc. (mm) threshold for rainy days

% product version label
version_label = 'v2.0_test';
```

Precipitación

Resultados y evaluación

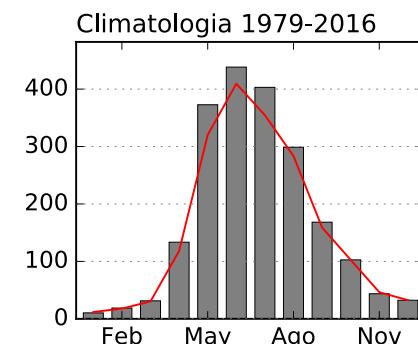
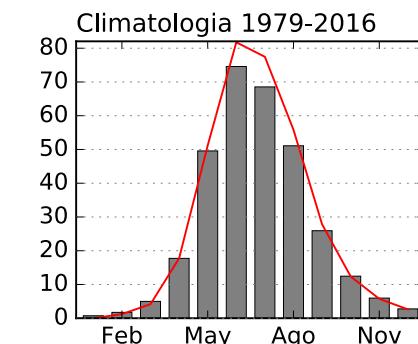
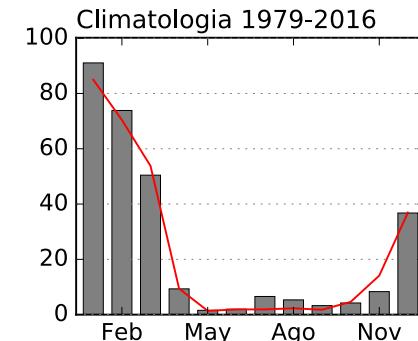
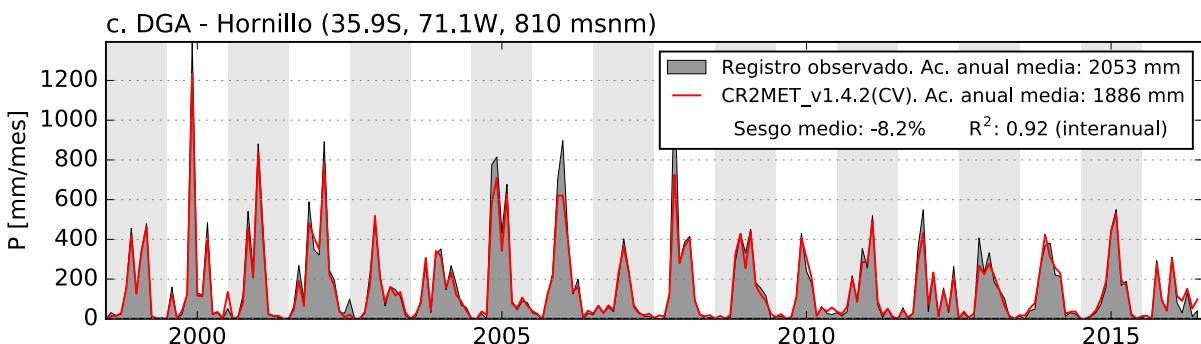
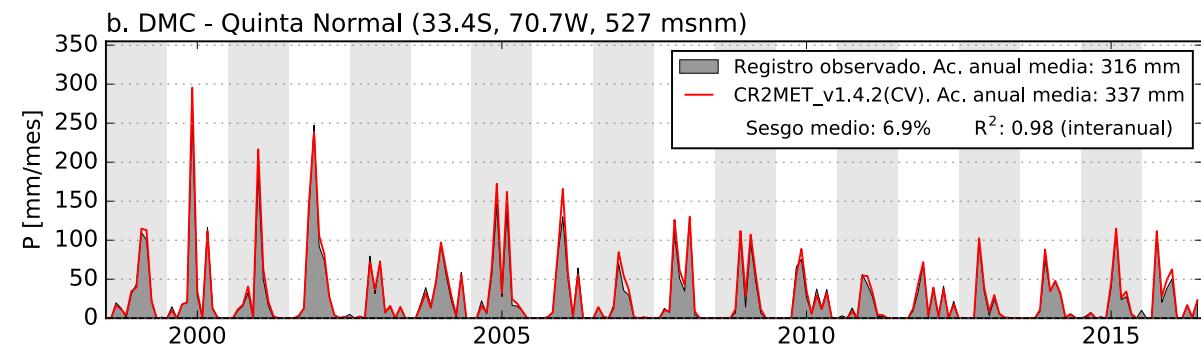
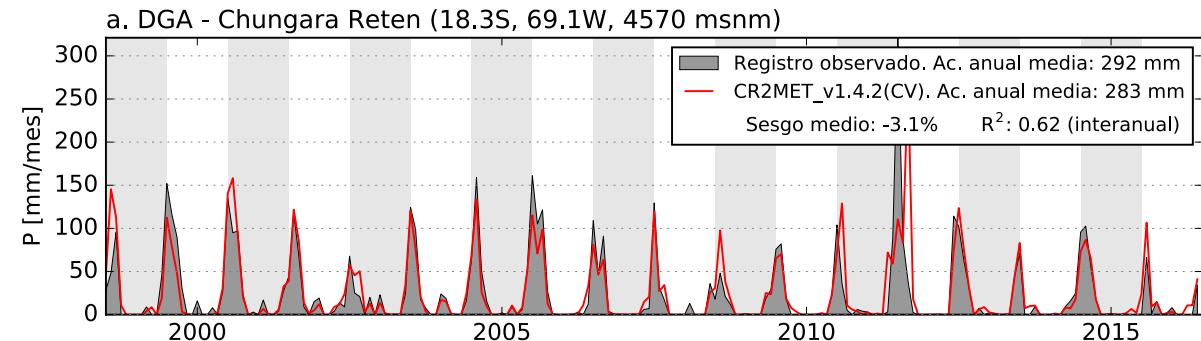
- Comparación con obs. locales
(validación cruzada)
- Comparación otros productos
- Contraste directo con caudales
(balance en cuencas)
- Modelación hidrología



Precipitación

Resultados y evaluación

Leave-one-out CV

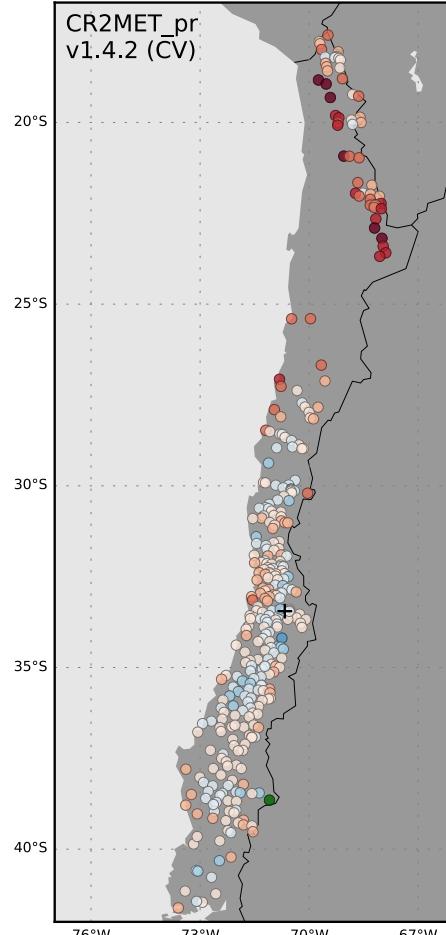


Precipitación

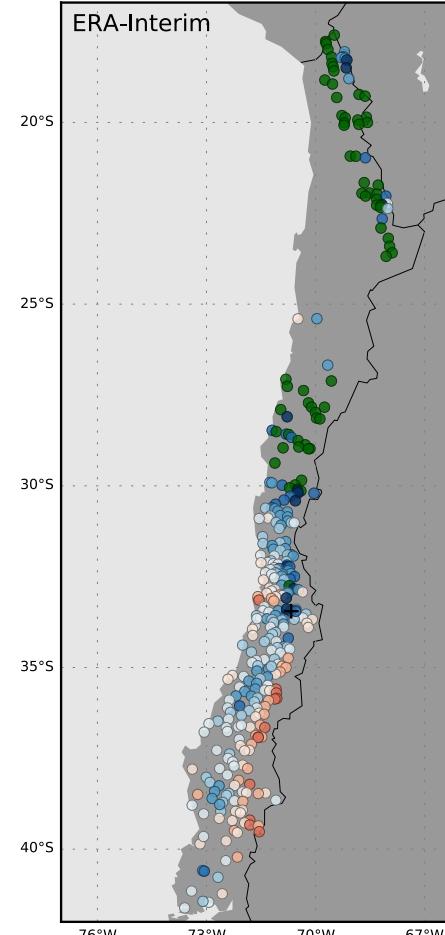
Resultados y evaluación

Leave-one-out CV

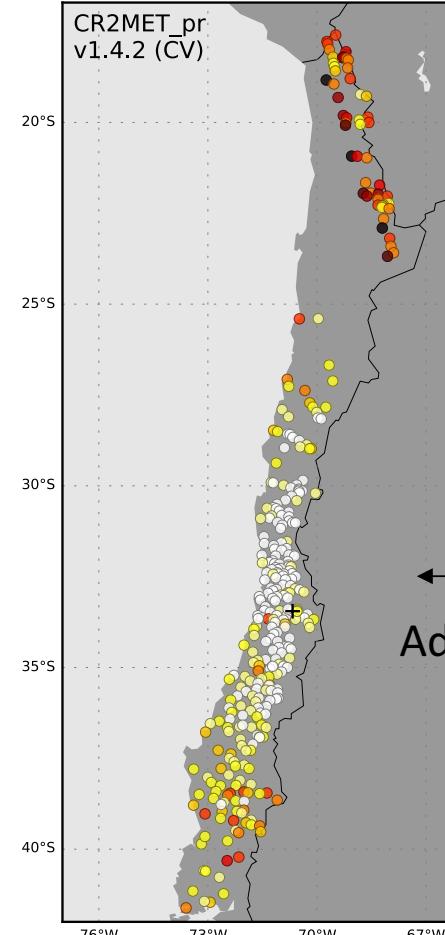
a. Sesgo medio



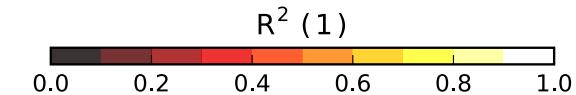
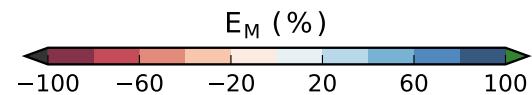
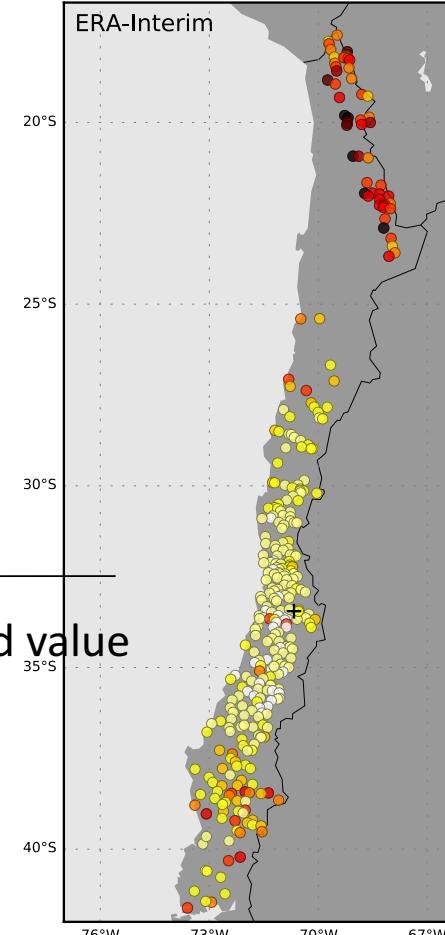
b. Sesgo medio



c. Coef. de determinacion

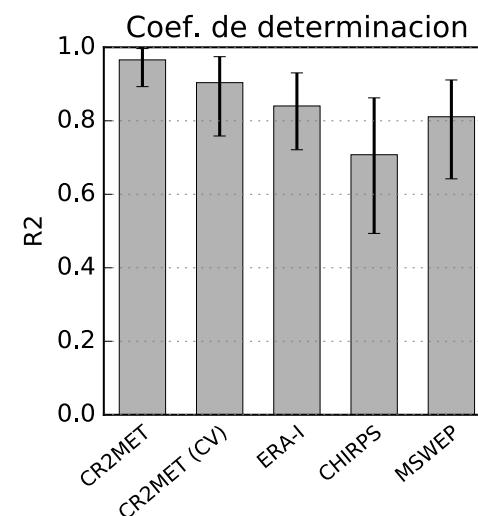
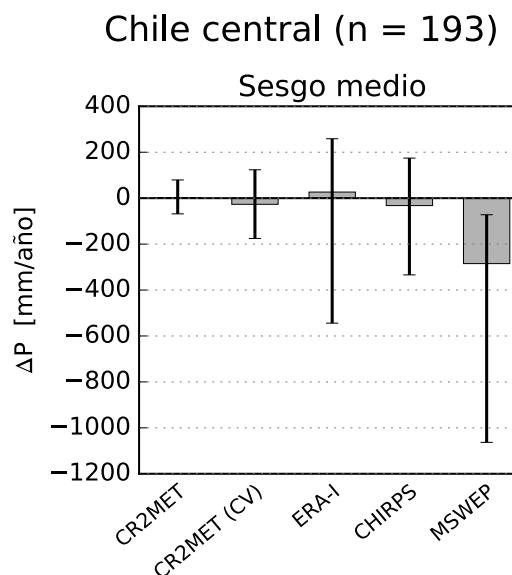
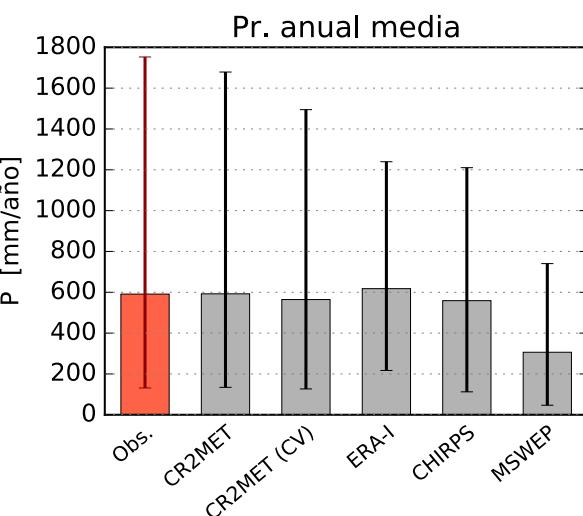
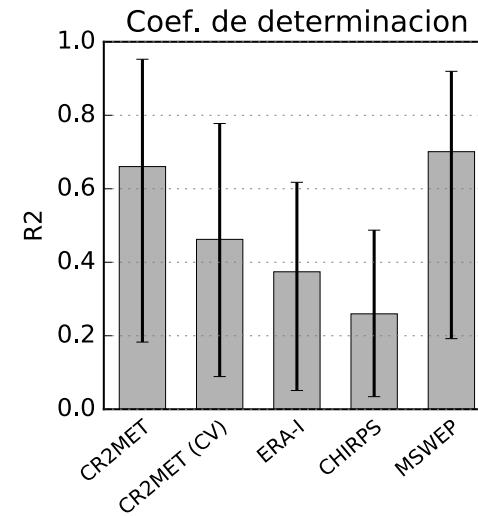
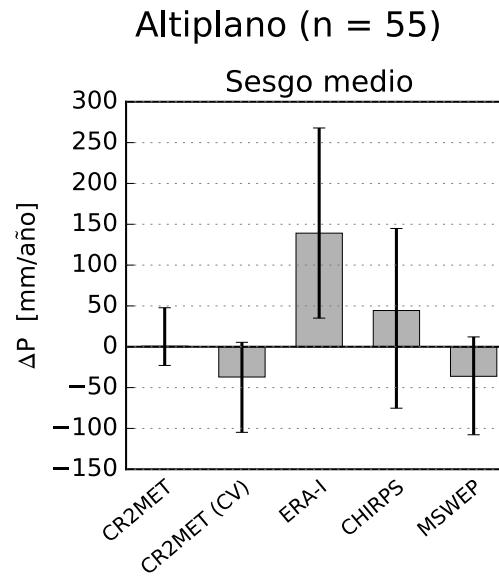
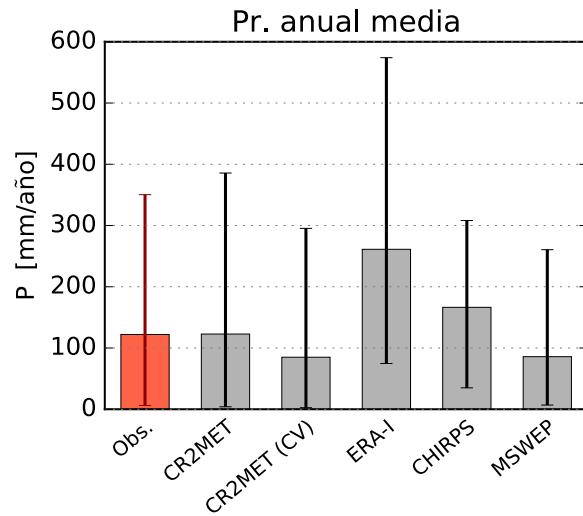


d. Coef. de determinacion



Precipitación

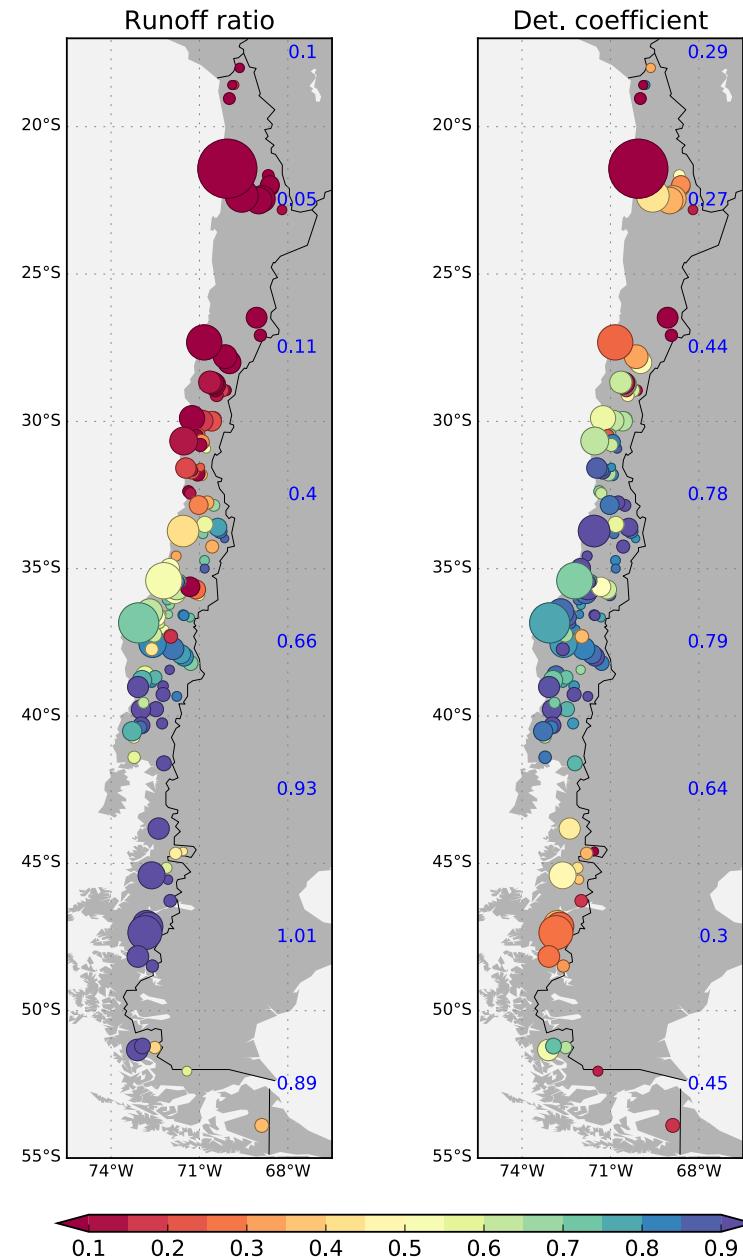
Resultados y evaluación



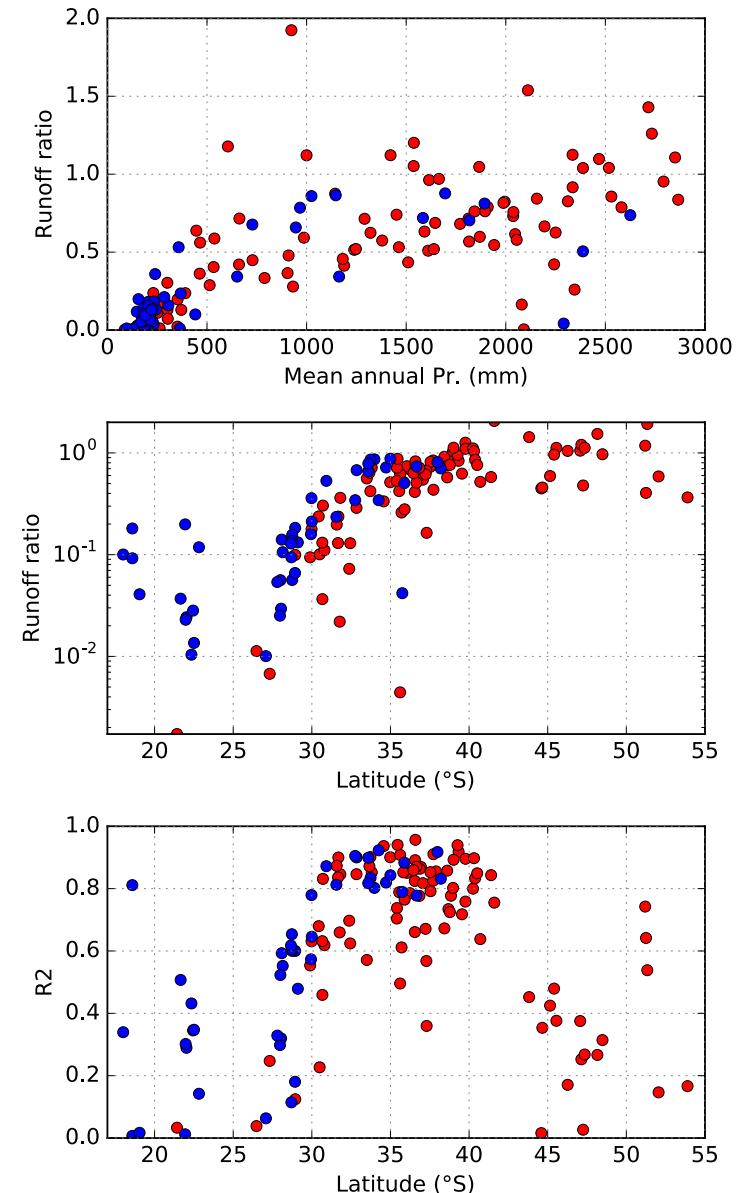
Precipitación

Resultados y evaluación

Integración sobre
Cuenca CAMELS-CL



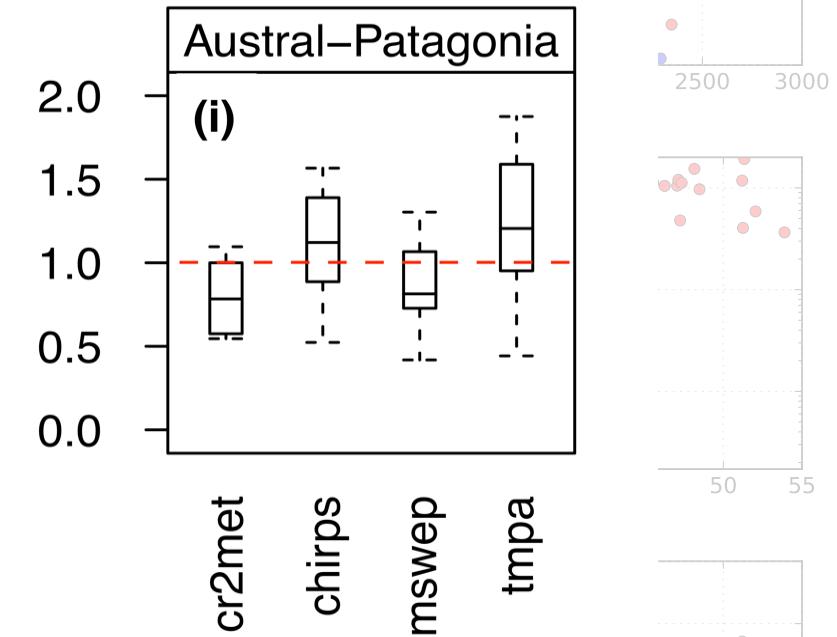
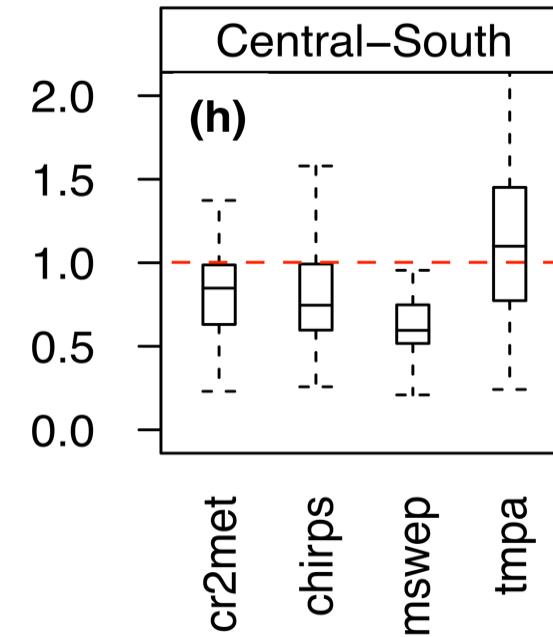
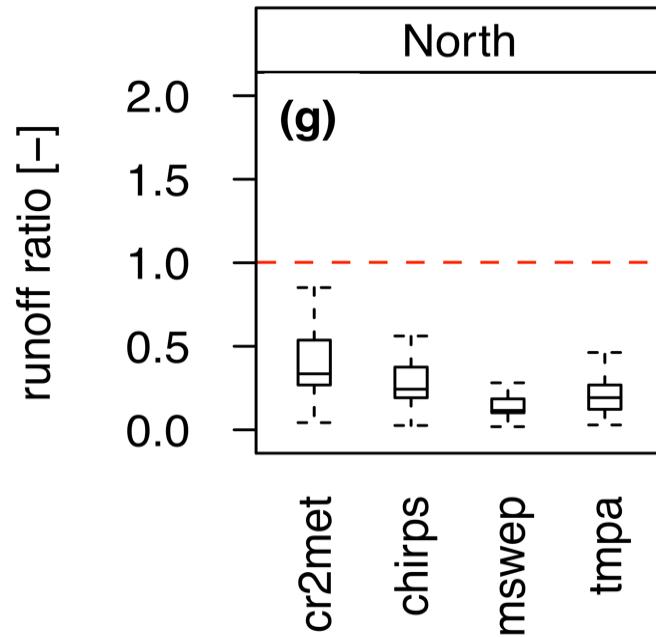
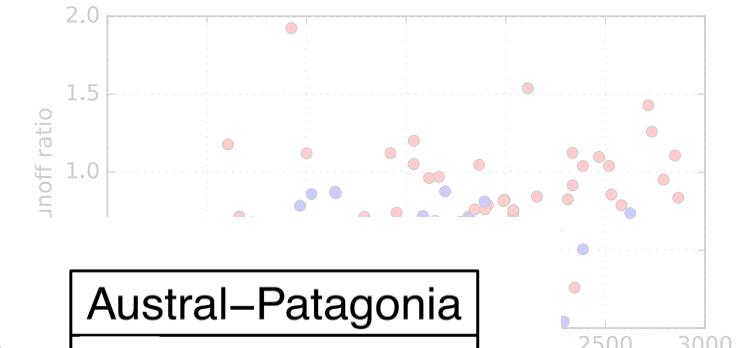
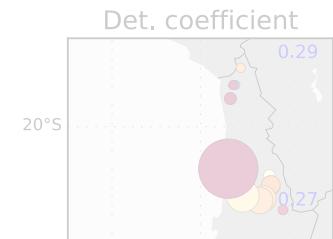
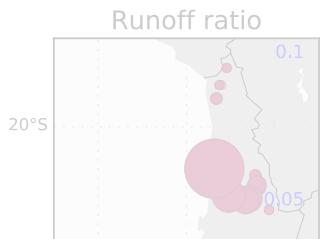
CR2MET_v1.4 | Basin-wide annual Pr. vs Q flux



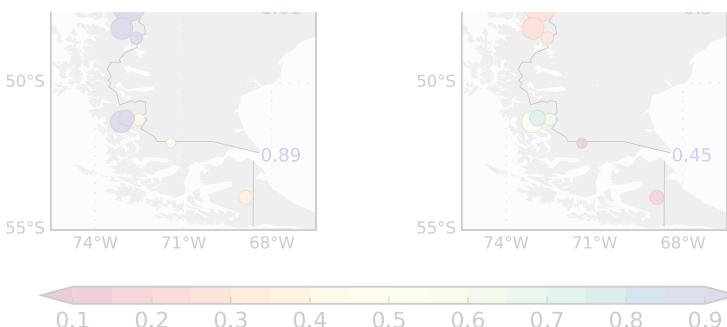
Precipitación

Resultados y evaluación

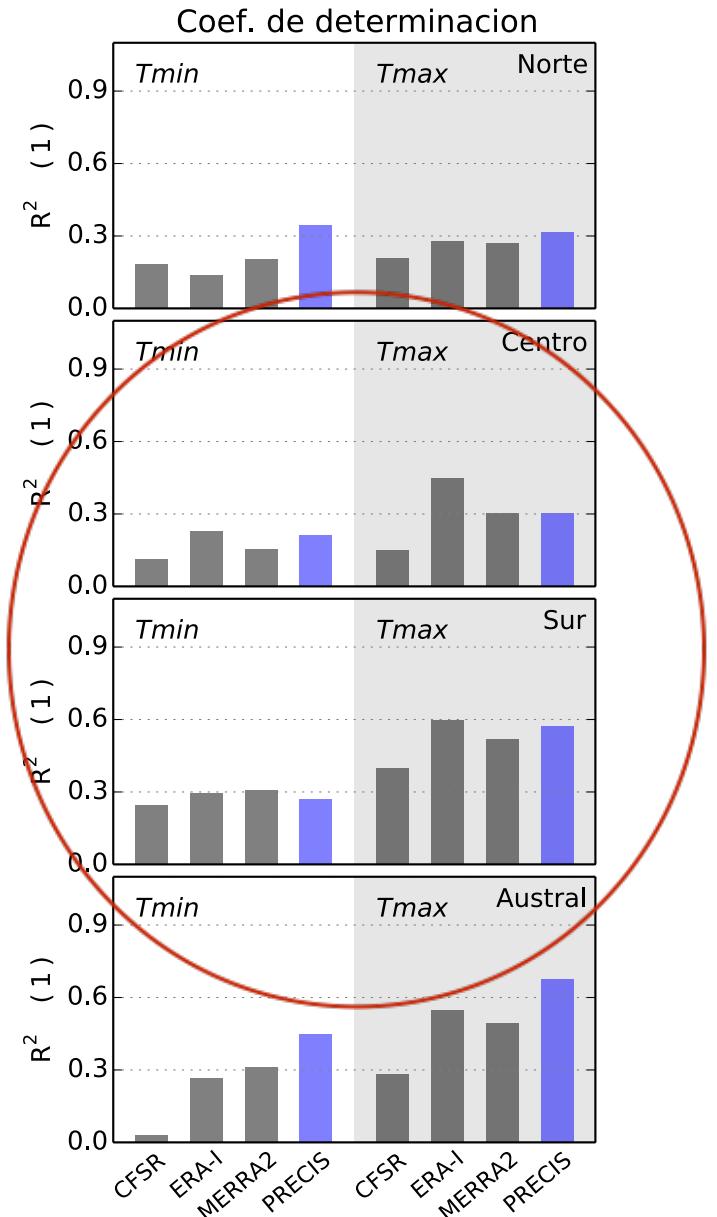
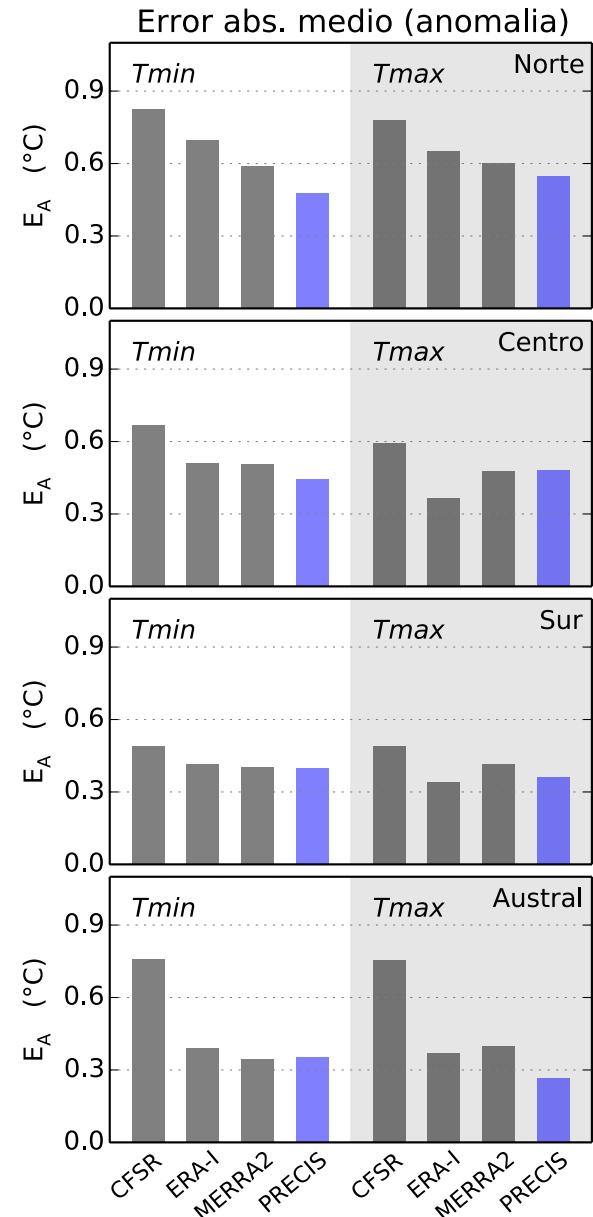
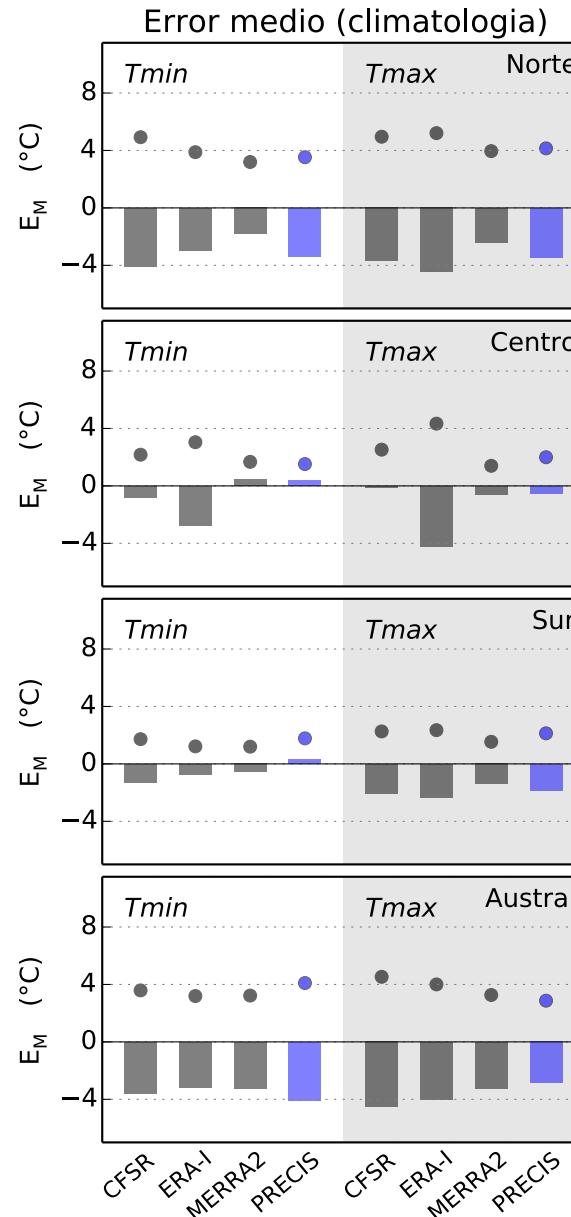
CR2MET_v1.4 | Basin-wide annual Pr. vs Q flux



Alvarez-Garretón et al. 2018



Temperatura (Tmax y Tmin)



Temperatura (Tmax y Tmin)

El método de *downscaling* usado para pr no funciona super para T

- Tx y Tn de reanálisis poco confiables
 - No se asimila t2m
 - Acoplamiento y LSM no muy buenos al parecer
- Efectos locales importantes para T (i.e. tipo de suelo) no se “ven” en los reanálisis y son difícilmente corregibles (pocas observaciones para discriminar tantas fuentes de variabilidad)

Opción CR2MET: Apoyarse en otro producto de T >> MODIS LST

- Disponible a la res. deseada (se soluciona, a priori, el problema del detalle regional)

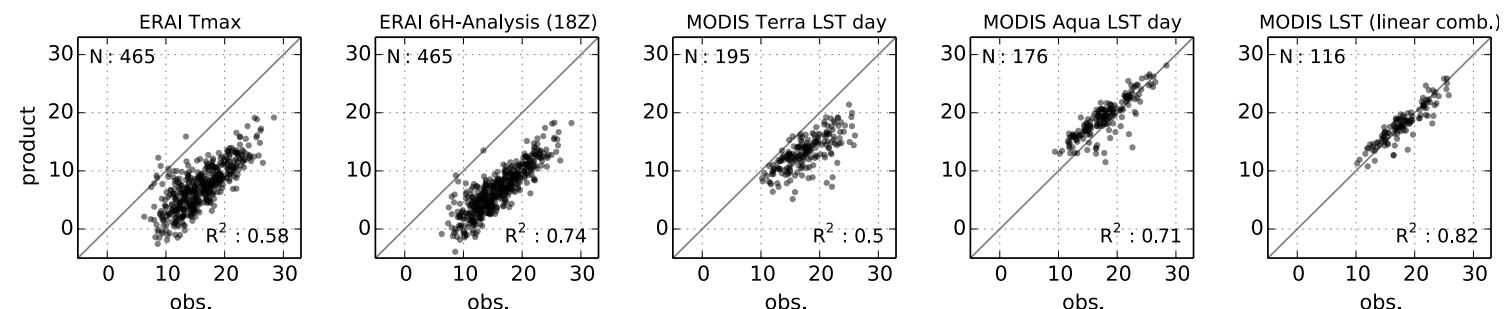
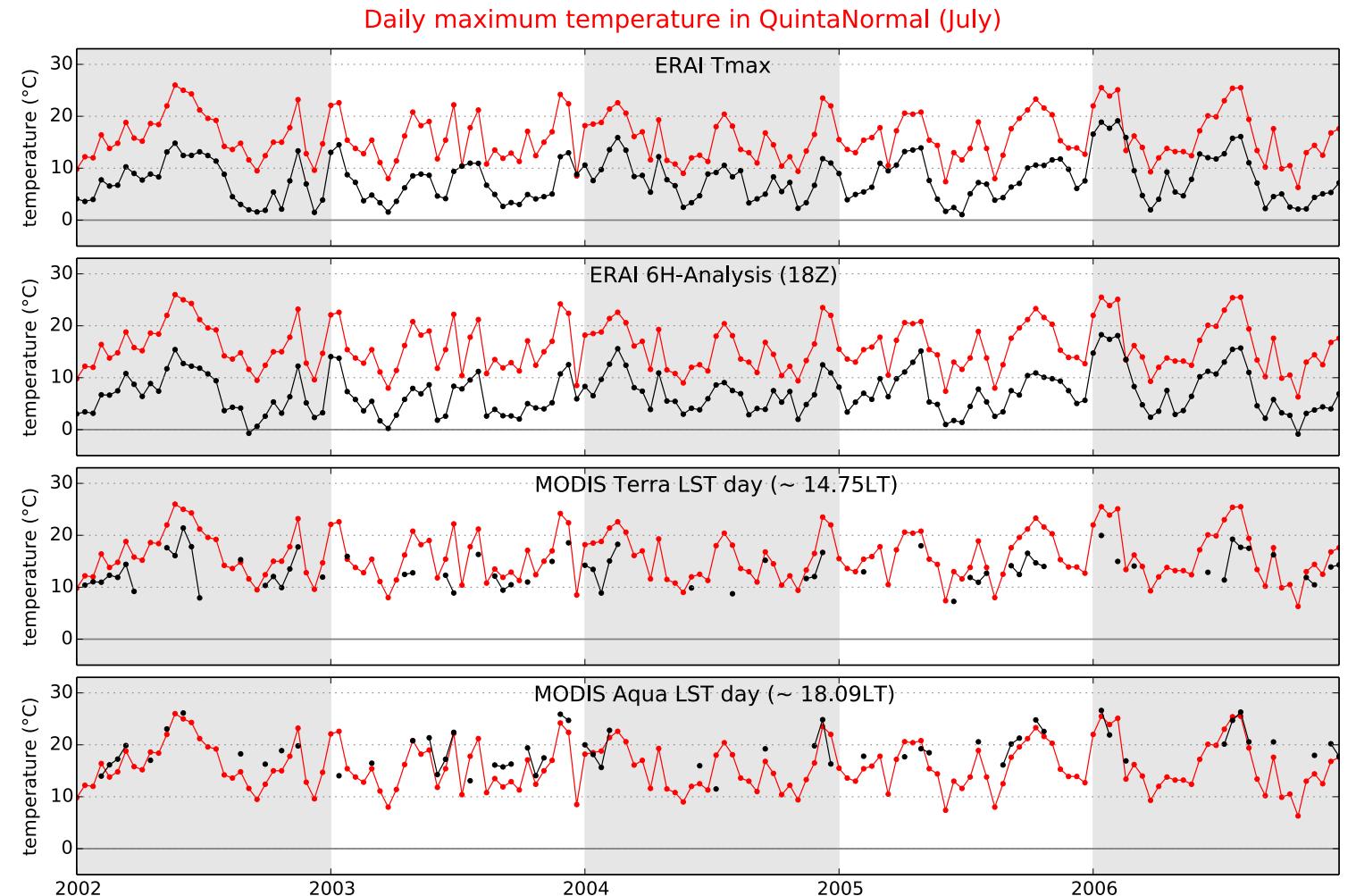
Problemas:

- LST es una estimación de T. superficial, obs. a ciertas horas... no es Tmax ni Tmin
- Periodo limitado (2002+) y sólo a cielo despejado

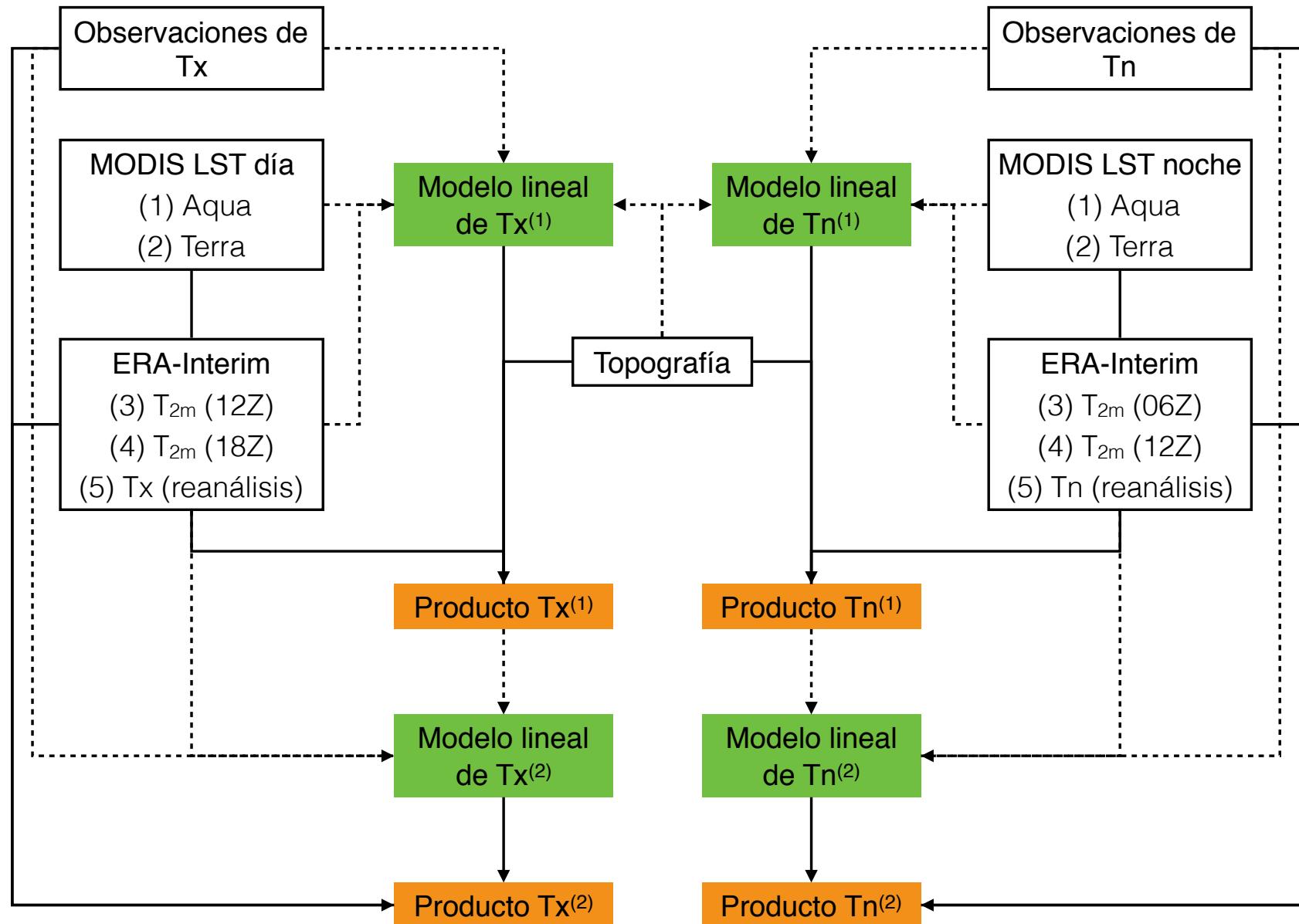
mmm...

Temperatura

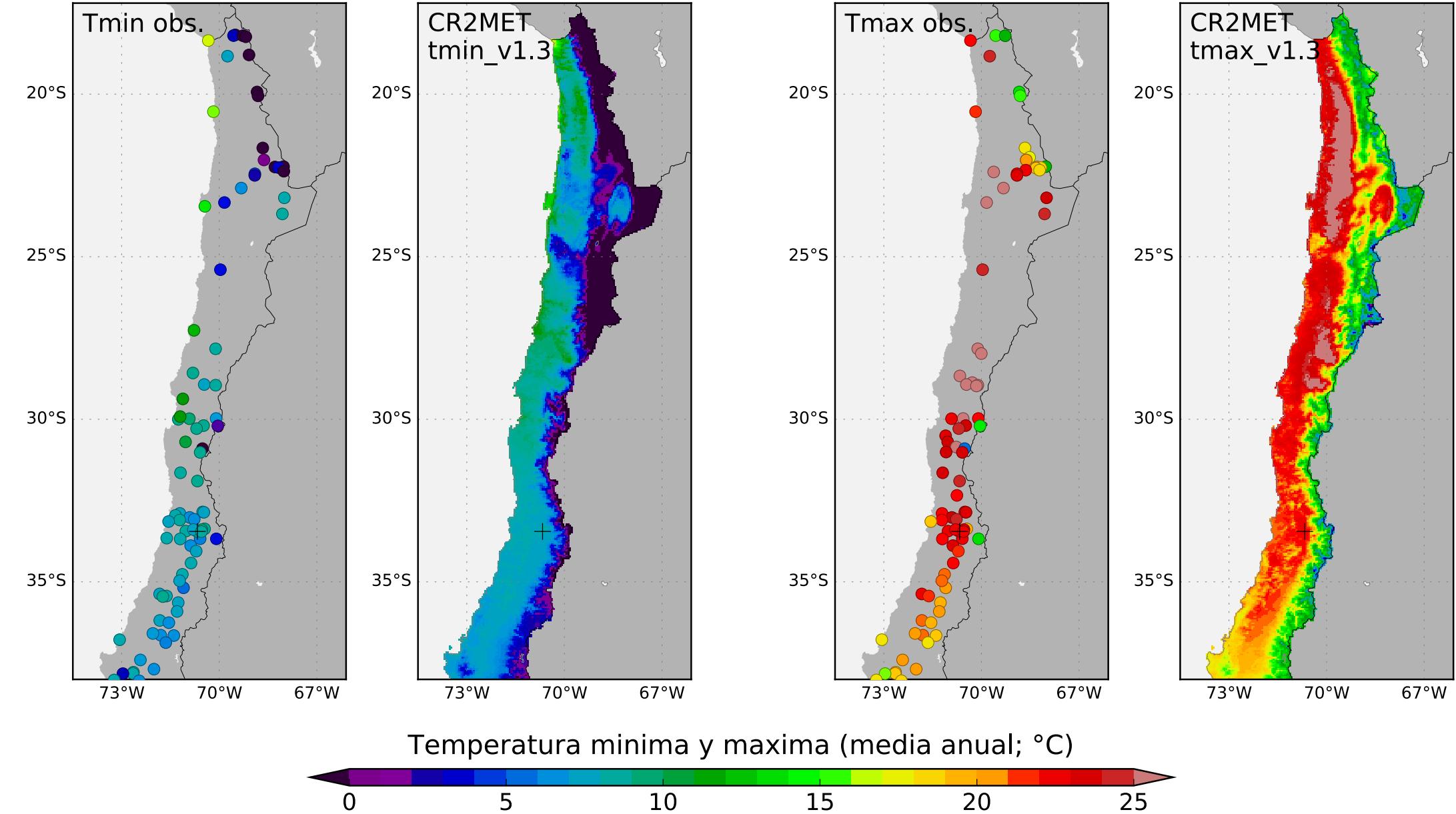
Ejemplo co-varianza
Obs., ERA-I y MODIS LST



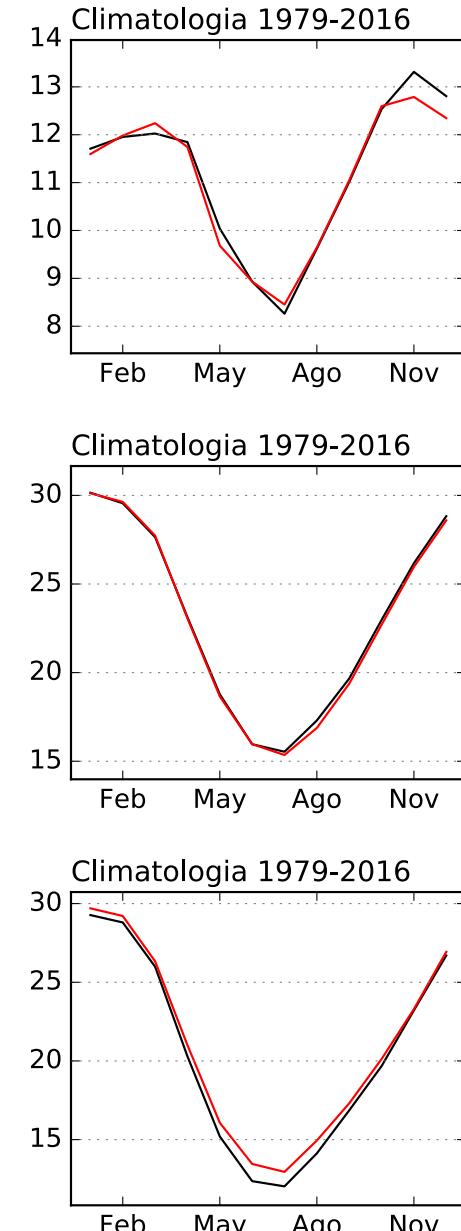
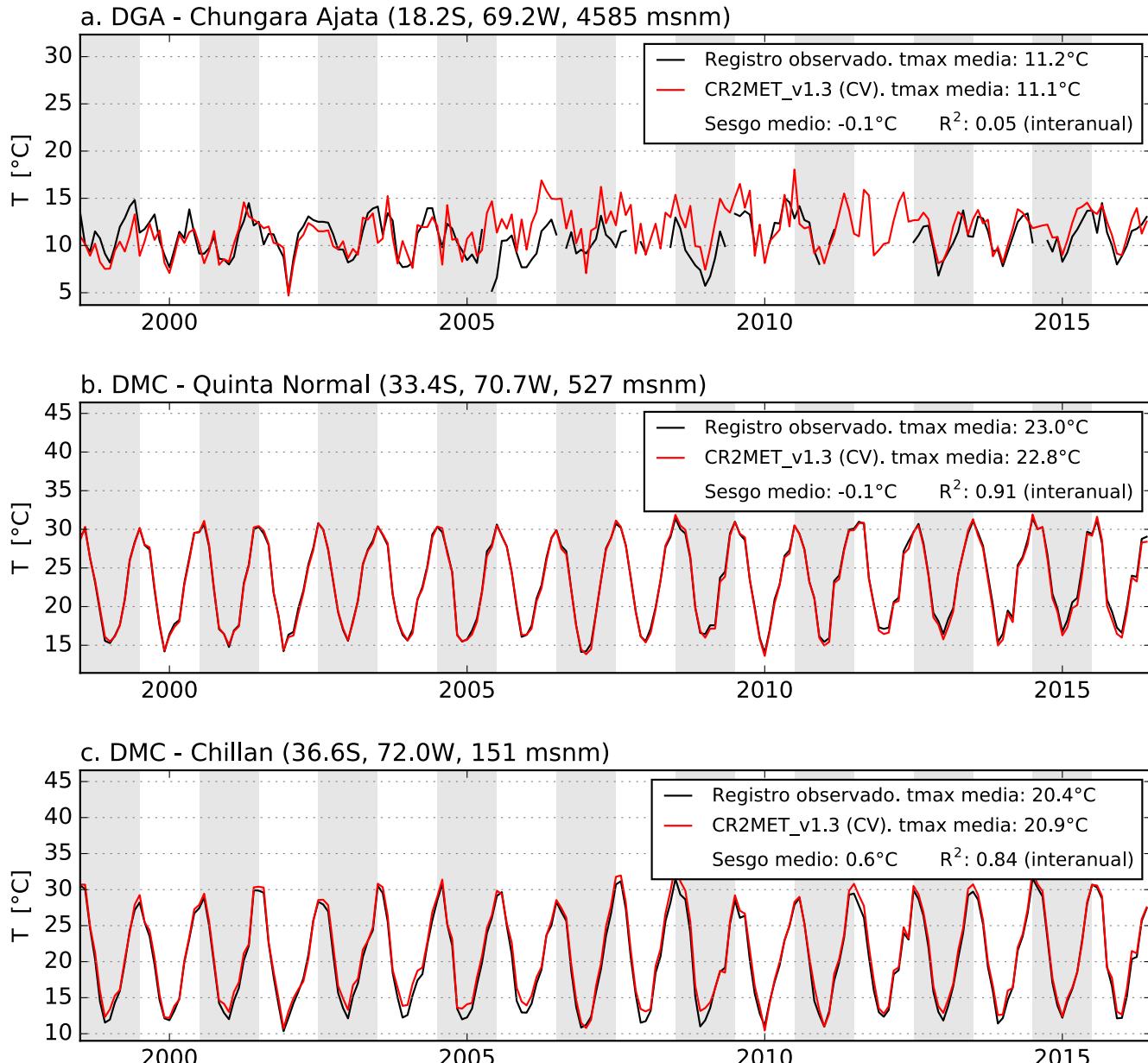
Esquema v1.3



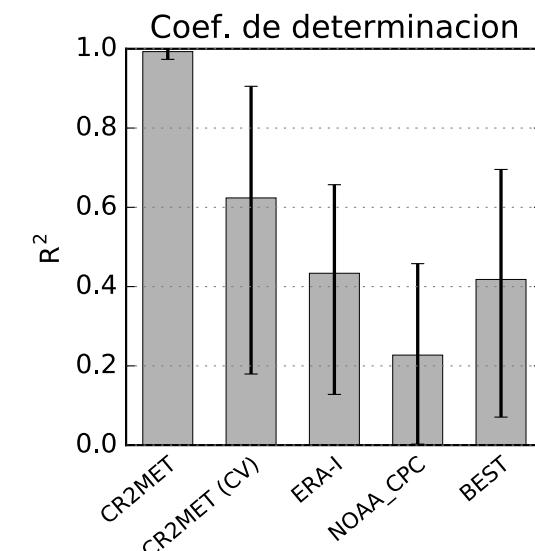
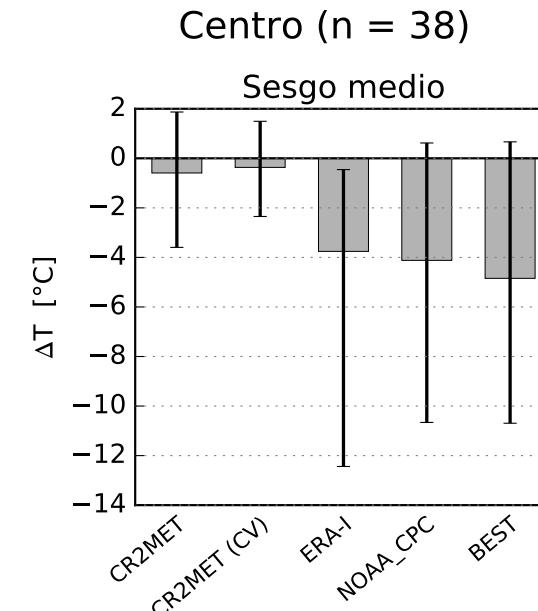
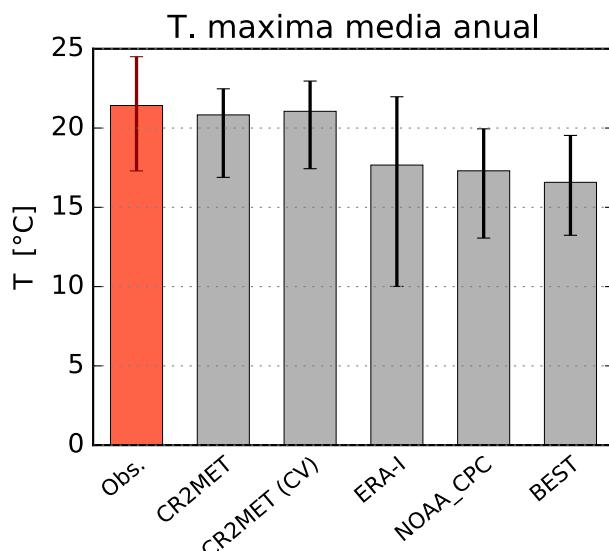
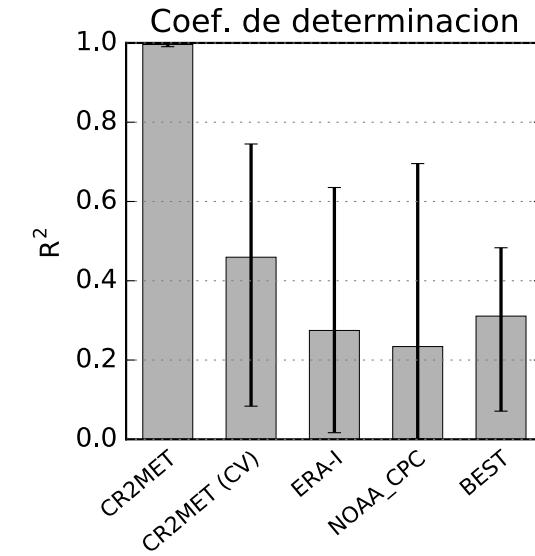
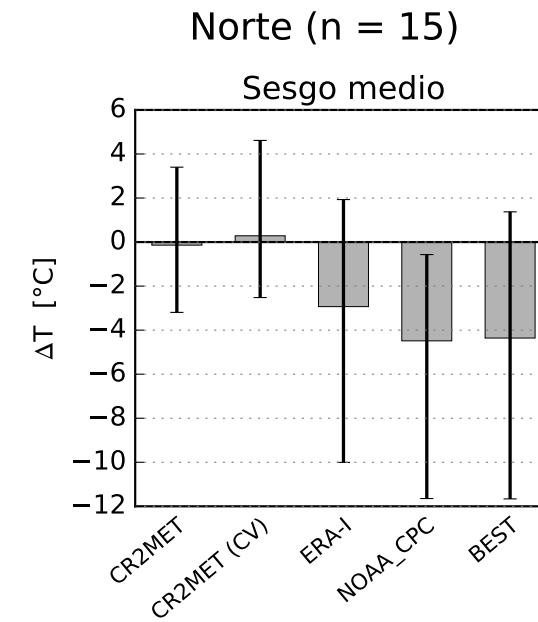
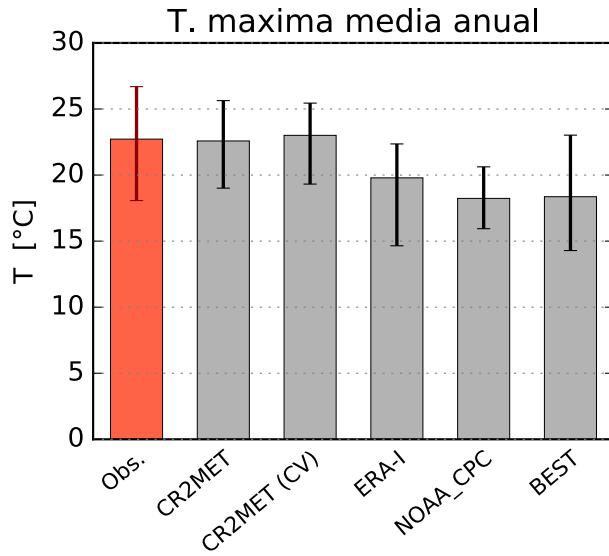
Temperatura



Temperatura

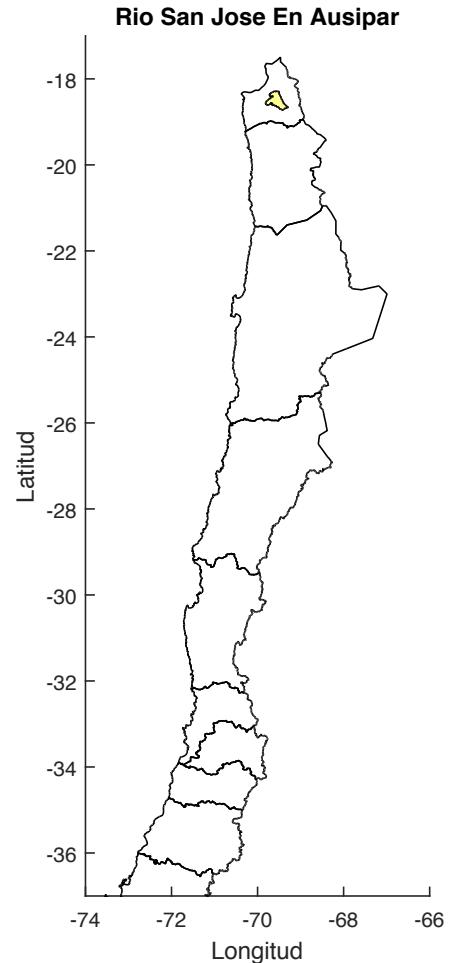
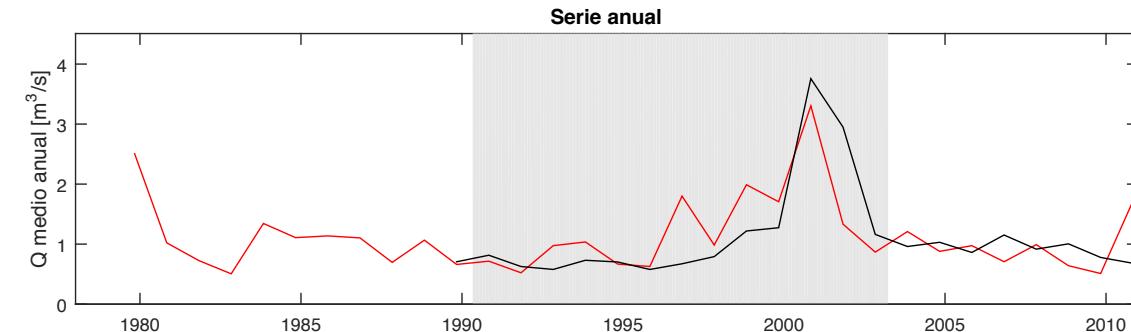
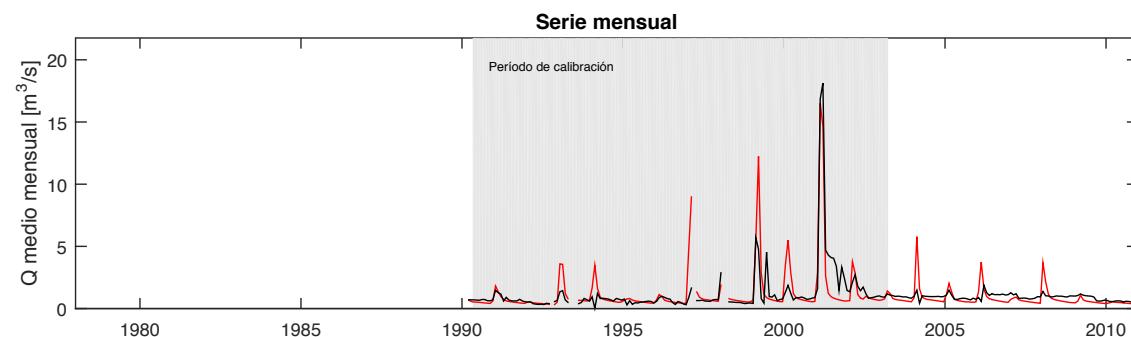
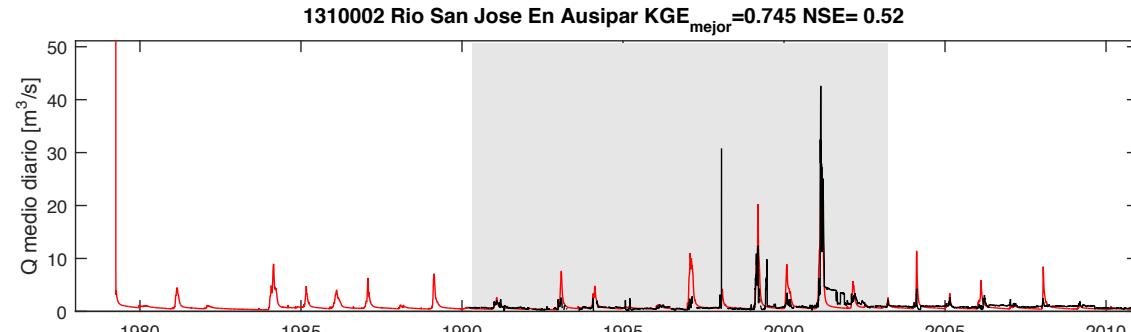
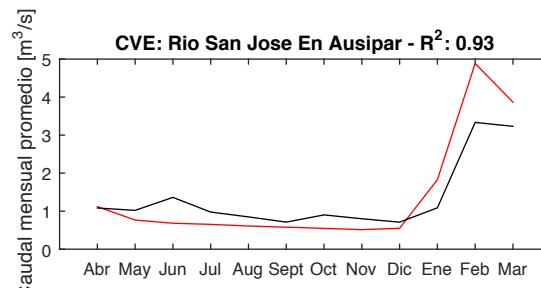


Temperatura



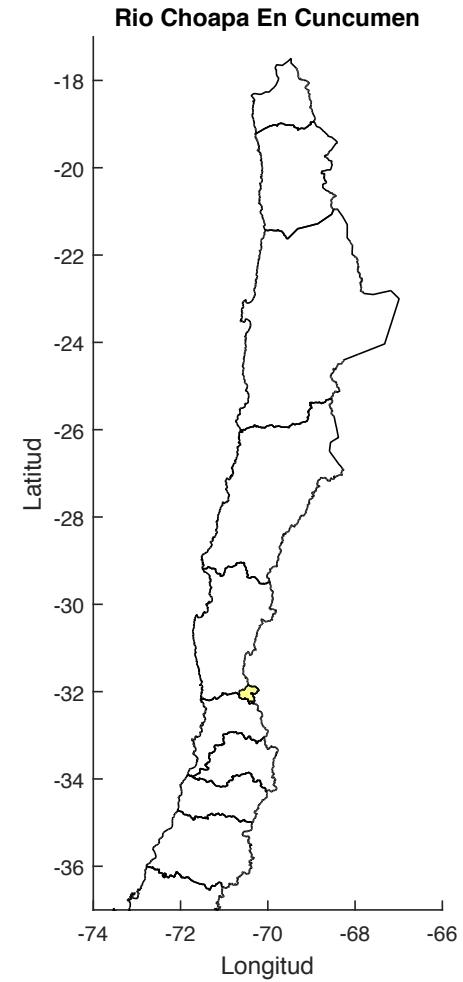
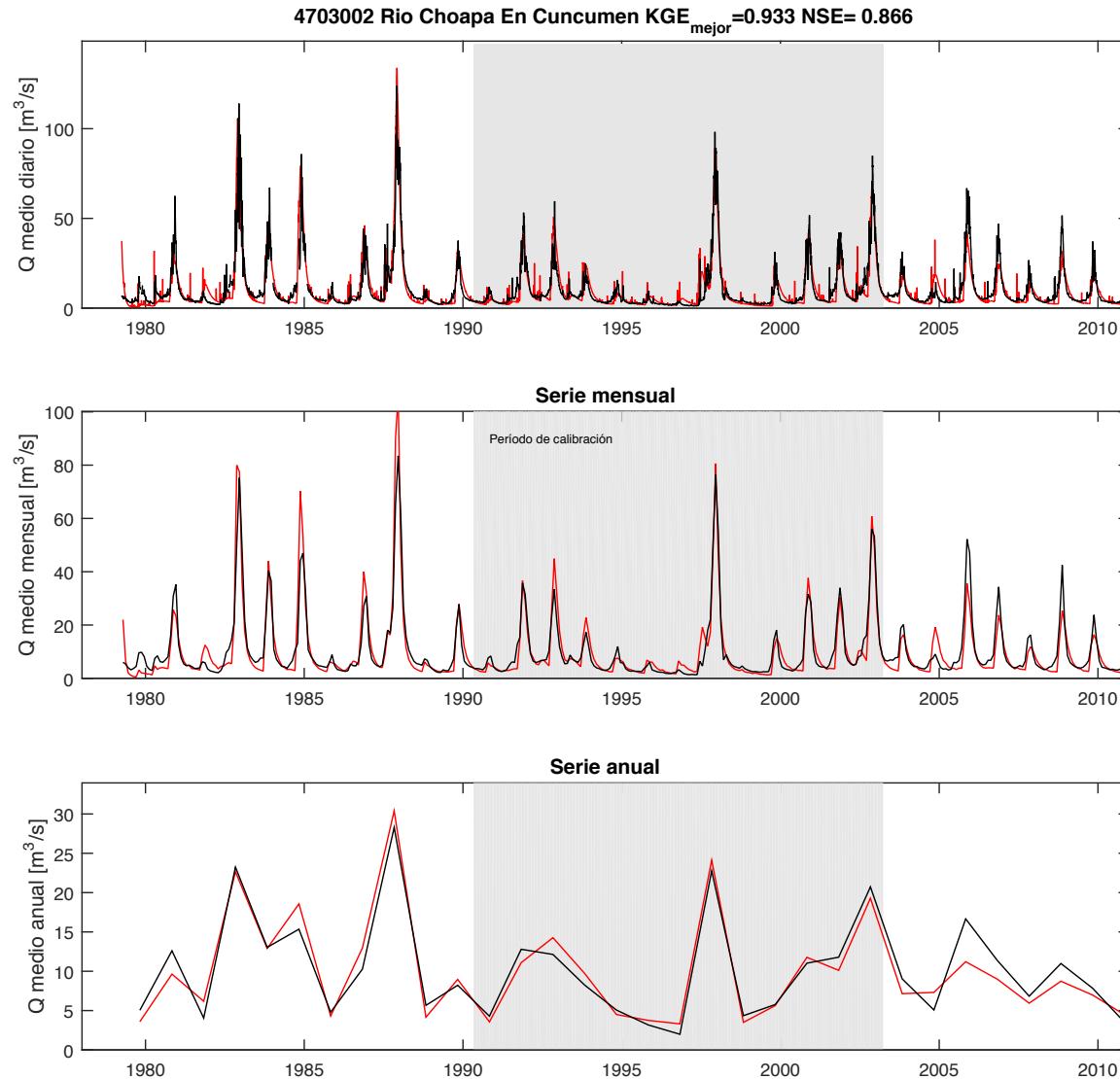
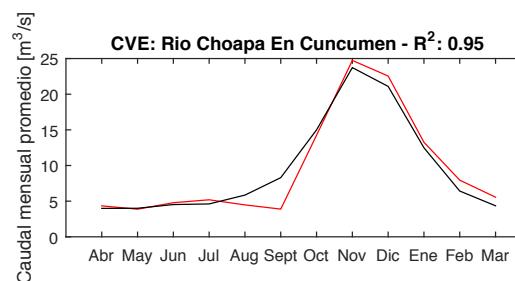
Evaluación general

Simulaciones hidrológicas con modelo VIC



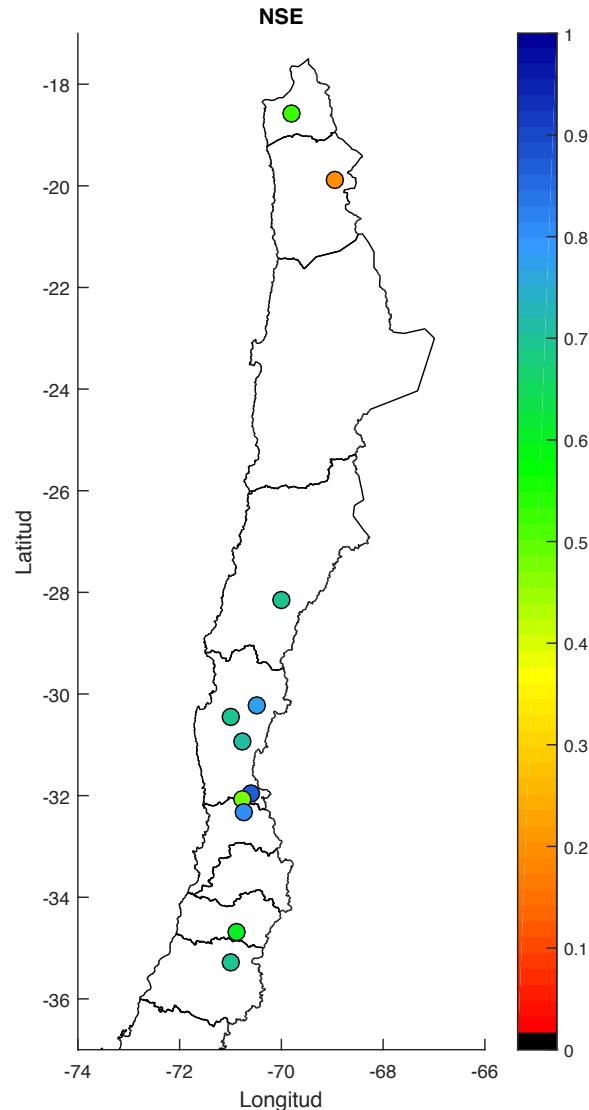
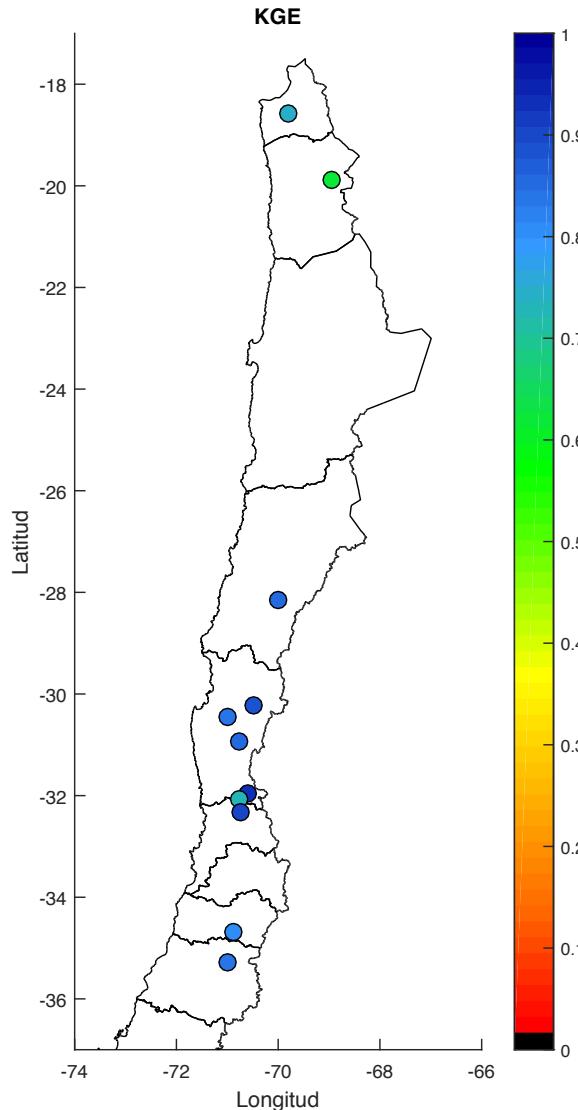
Evaluación general

Simulaciones hidrológicas con modelo VIC



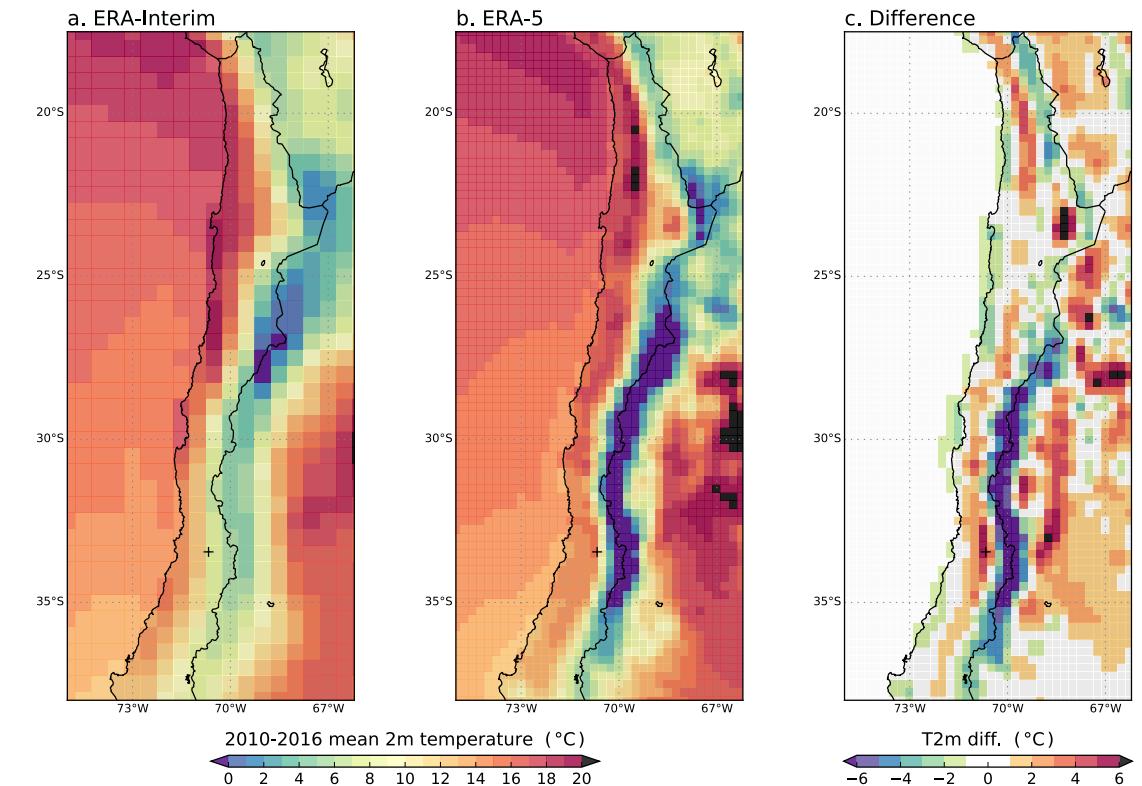
Evaluación general

Simulaciones hidrológicas
con modelo VIC

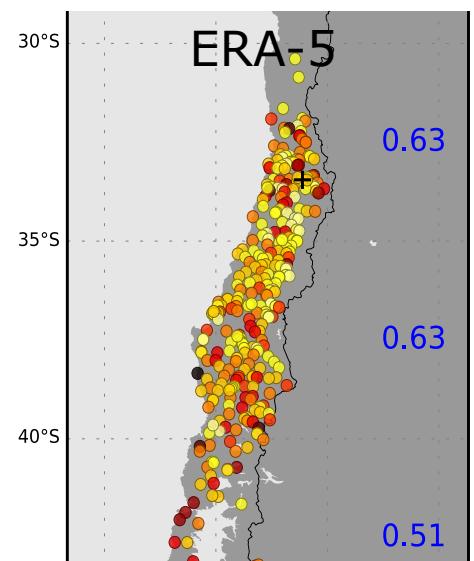
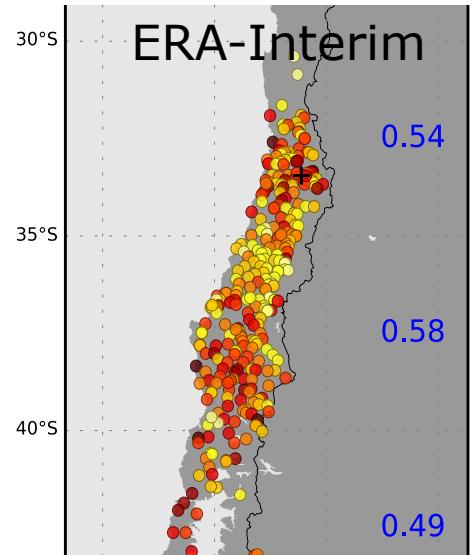


- Actualmente, las datos CR2MET se almacenan en qhawayra (CR2)
- Acceso página CR2 o ftp (full dataset)
 - ftp://qhawayra2.dgf.uchile.cl/gridded_products/cr2met
- Archivos netcdf
 - Desde txn_v1.3 y pr_v1.4
 - Archivos compactados (int16)
 - se debe formatear a precisión simple o doble, y escalar al leer !
 - Un archivo por año (day)
 - Un archivo todo el periodo (month)
 - LTM: long-term mean
 - alldom: archivos con datos fuera de Chile (ERA-Interim)

- Se incluyen componentes convectivas y de gran escala de P
- Ajuste climatologías segun datos ERA-5 (2000-2016)
- $P_{\text{blend}} = P_{\text{ERA-I}} \frac{\text{mean}(P_{\text{ERA-5}})}{\text{mean}(P_{\text{ERA-I}})}$



- Full ERA-5
- Nuevo código (re)muestreo de datos
- Semi-operativo
 - Se correrá en servidores CR2
 - Versión definida por calibración (cada ~ 1 o 2 años)
 - Puesta al día independiente de calibración
 - Simple & rápido (mensual ?)
- LST: MOD11 > MOD21 ?



Covariabilidad Pera, Pobs
inter-diaria (invierno)

